Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

JANUARY 1958

8-PAGE ARS MEETING REPORT

Solid Propellants and Space Flight. . .*Harold W. Ritchey*
Aspects of Vanguard Propulsion. . . . . .*Kurt R. Stehling*
A Look at Free Radicals. . . .*G. C. Szego and E. A. Mickle*

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A PUBLICATION OF THE AMERICAN ROCKET SOCIETY, INC.

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January 1958 — *volume 3* — *number 1*

EDITORIAL

ARS ANNUAL MEETING

FEATURES

SOVIET AND U.S. SATELLITES

NEWS

DEPARTMENTS

at press time

Up-to-the-minute news about the rocket, guided missile and jet propulsion fields

SATELLITES

• All eyes are on Cape Canaveral—or so it seems to the hard-pressed inhabitants. Big news, of course, was the failure of first U. S. satellite try due to loss of thrust shortly after first-stage ignition.

Now the world is waiting for the second satellite shoot. Navy is already preparing another Vanguard vehicle and satellite for launching. This time, the Navy hopes there will be less publicity and pressure on project personnel. However, the Army, readying a Jupiter C for a satellite launching, may do the job first.

MISSILES

• Air Force made first successful Atlas firing on third try. First two firings went awry and missiles had to be destroyed by ground control.

• Meanwhile, the day after the first Vanguard failure, the Air Force launched its seventh Thor IRBM. It landed short of the intended target area. Another Thor, fired about two weeks later, went the distance, giving the Air Force about a .500 average for its first eight firings.

IGY

• NRL will fire six to eight instrumented rockets in IGY solar eclipse program in October. Shipboard launchings in Southwest Pacific are planned, with all the rockets (Nike-Cajuns or Nike-Asps) to be fired within a period of four minutes.

R&D

• Col. John Stapp, newly elected ARS vice president, has been named coordinator and advisor to Brig. Gen. Donald Flickinger, ARDC chief of Human Factors, on "Man in Space" research program, concerned with development of manned orbital satellites and manned space flight. Col. Stapp's job will be to organize aeromedical resources.

• Aerophysics Development Corp. recently completed a feasibility study for the Air Force on balloon-launched rocket firings. Company concluded elevation and azimuth of rockets could be controlled and monitored in launchings up to altitudes of 100,000 ft.

Aerophysics is also working on a number of other projects. Among the more interesting: A small, inexpensive furnace that will produce temperatures of 2500–3000 C; a low-cost plasma jet generator; and extruded rocket bodies.

• According to well-informed sources, Lockheed Aircraft Corp., already a leading producer of missile airframes, is now seriously considering going into the rocket engine business. Company has a newly organized facility on the West Coast that could be used for production.

• Stauffer Chemical Co. is working under contract to the Navy on development of high-temperature polymers for missile applications. Polymers are based on fluorine, contain boron and a minimum of carbon; and, according to one company spokesman, will withstand temperatures above 500 C. Some possible applications: Imbedding compounds for electronic parts, wire coatings, hydraulic fluids and propellant expulsion bags. Stauffer stresses polymers' advantages in those tasks calling for contact with propellants.

• Bell Aircraft is pushing small hydrogen peroxide rockets for missile control applications, particularly for jobs where throttleable control is needed. Developed by Bell in connection with its work on the early X-planes, the peroxide rockets will

produce 40 to 50 lb thrust. Duration would be limited only by size of peroxide tank.

AMATEUR ROCKETRY

• A long series of accidents involving amateur rocket experimenters is alarming responsible groups who feel such work should be supervised by those with know-how and should take place under the same conditions as professional projects.

Some ARS sections have already begun doing something. The work of the National Capital Section, as described by Lt. Col. C. M. Parkin at a luncheon at the Annual Meeting, deserves particular commendation. This program includes professional evaluation of each amateur project and arrangements for test firings on government ranges when indicated by the evaluation.

Up along the Niagara Frontier, Robert Roach, a preliminary design engineer from Bell, has been waging a one-man campaign for a "safe and sane" amateur rocketry program for high-school youths. At the Annual ARS Meeting, Roach found an attentive audience in some Grand Central Rocket Co. personnel who expressed interest in producing a small, safe solid propellant rocket motor for the amateur market.

EDUCATION

• Latest word from University of California is that over 1000 persons have registered so far for the course in Space Technology which gets under way this month.

PROPELLANTS

• Market for missile propellants apparently is shaping up as less of a gamble than was first thought by major chemical process industry firms.

Dow Chemical Co., already in the missile field with its magnesium alloys, is now taking the first step toward production of rocket propellants—and an unusual first step it is. Company is going to missile makers asking them what is wanted or needed in the way of propellants.

On a somewhat more tentative level, Conoco (Continental Oil Co.) representatives are sounding out leading liquid propellant men on possibilities and potentials of specific high-energy chemicals as future missile propellants.

• The possibility of using hydrogen as a rocket fuel seems to have passed beyond the conjectural stage. Trade magazine Chemical Week reports three AF projects, code-named Baby Bear, Mama Bear and Papa Bear. (One source refers to them as Little Bear, Middle Bear and Big Bear.)

Baby Bear is reported to be a pilot-plant operation in Painesville, Ohio, and the other two are said to be large-scale versions at Cape Canaveral. Air Products and Linde are the two firms involved in the projects and are believed to have received $100 million for the work.

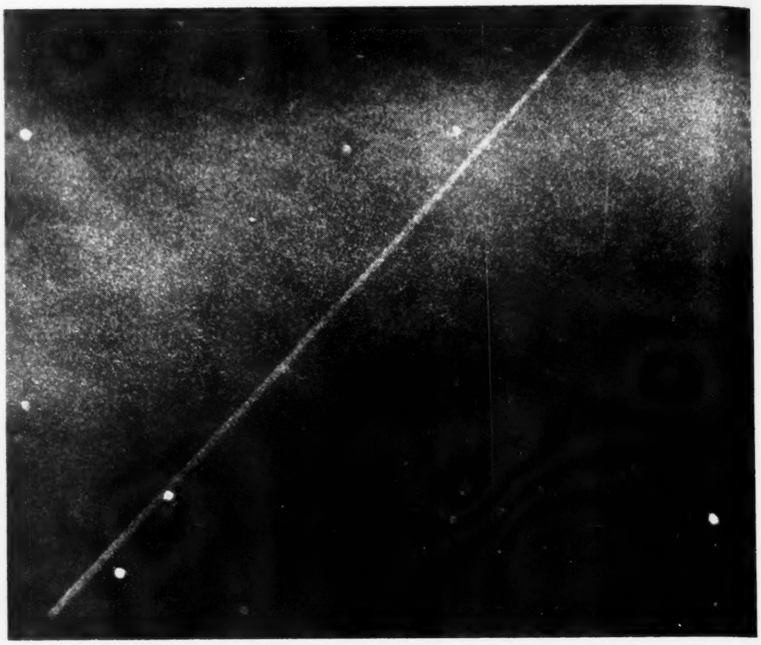
Until recently, two major drawbacks to the use of liquid hydrogen have been storage and handling. Now scientists at the Bureau of Standards have developed a new technique that is said to ease the problem significantly. It involves the conversion of unstable orthohydrogen into stable parahydrogen, using hydrous ferric oxide as a catalyst.

ROUNDUP

• Defense Dept. may convert Army's 40th Field Artillery Missile Group into the first IRBM team and send it abroad late this year . . . U. S. and England have agreed to establishment of four IRBM squadrons (three British and one American) in England. Sites will cost $84 million, to be borne mostly by Britain . . . Air Force will spend $46 million on construction of four Bomarc sites to be set up at Bangor, Me.; Falmouth, Mass.; Westhampton Beach, L. I.; and Wrightstown, N. J. . . . Convair has installed huge 100-g centrifuge for Atlas test program . . . General Bronze Corp. has completed design of a 400-ft radio telescope for radio astronomy applications . . . ARDC reports that a new General Electric high temperature, silicon hydraulic fluid has proven itself in the temperature range from —65 to 575 F . . . Commercial Solvents Corp. recently released technical data sheet No. 23D on "Use of 2-Nitropropane as a Rocket Fuel."

In Sputnik's Wake: Soviet Claims and Western Skepticism

The initial amazement and chagrin of the Western world following the launching of the first two Soviet satellites soon gave way to deep concern. During these early days, the Russians fully exploited the rich propaganda potential of her scientific coups, and found the West willing to believe almost anything.



Five-second exposure of Sputnik II. Picture was taken by ARS Central California Section members at Santa Barbara at 5:30 a.m., Nov. 6.

Gullibility Draining Away

Now, even while the satellites are still orbiting, this gullibility is beginning to drain away, and the healthy scientific skepticism of old is taking its place, meeting each new Russian claim as it appears. Items under contention:

- Soviet scientist Vitaly Ginzburg claims the satellites have opened the way to experimental proof of Einstein's theories of the cosmos and to solution of other major astronomical problems.
- According to scientists who attended the recent meeting of the British Institution of Electrical Engineers, the Soviet satellites have yet to reveal anything particularly new about the boundaries of space around the earth.
- Diameter of the earth, according to Soviet scientists, is 26.7 miles less through poles than through equator. It's 27.3 miles less, say Western scientists. And a close check on the migration of the satellite orbits (caused by the equatorial bulge) corresponds closely with the pre-sputnik estimate based on the 27.3 mile difference of the Westerners, according to calculations of scientists at the Smithsonian Astrophysical Observatory.
- Dr. A. Varela Cid, director of Portugal's Centro de Estudos Aeronauticos, doubts that the Russians have actually launched any satellites and challenges them to prove it.

"This test proof should take place, at a locale to be agreed upon, at three astronomical observatories, during a moonless night when it will be possible to confirm the altitude of 12,750 km, which already corresponds to a speed of approximately 9000 meters per sec, this speed having been granted a certain bonification in relation to the speed of the artificial satellite."

Reserve Units Get Missile Training

Reserve Patrol Squadron 834, based at Floyd Bennett Field, Brooklyn, N. Y., recently became the first Naval Air Reserve Squadron to fire guided missiles as part of regular training.

Missile used by the unit was the air-to-surface Petrel, designed for action against surface ships and submarines. Capt. James H. Newell, commanding officer of NAS, New York, stated that increasing emphasis is being placed on antisubmarine warfare because of the substantial increase in submarines produced by Russia since World War II.

The Air National Guard has meanwhile started to re-equip its 123rd Fighter Interceptor Squadron (Portland, Ore.) with F-89H aircraft. The F-89H is the late model Northrup Scorpion, which is equipped to carry the Falcon air-to-air missile.

Paralleling these moves, according to a recent announcement by Secretary of the Army William Brucker, is the conversion of Army National Guard antiaircraft artillery units to Nike ground-to-air missiles.

Artificial Meteors Successfully Fired

The Air Force recently revealed that on Oct. 16 a research team from the Air Force Cambridge Research Center had fired small, artificial meteors out into space from Holloman Air Force Base.

The meteors, fragments of aluminum about the size of small ball bearings and weighing only a few grams each, were propelled by three shaped charges fitted into the nose cone of an Aerobee. The nose cone separated from the rocket at an altitude of 35 miles. At 54 miles, the three charges—weighing between 2 and 5 lb and from 6 to 8 in. long—were detonated simultaneously.

The resultant speed of the small aluminum fragments was estimated to be 40,000 mph and it is believed that at least two of the pellets had escaped the pull of the earth's gravity and would end their interplanetary trip by speeding into the sun, some 93 million miles away.

According to Maurice Dubin, physicist in charge of the project, this may well be the first time that man has propelled any object beyond the earth's gravitational field.

Fritz Zwicky, California Institute of Technology, and T. C. Poulter and M. C. Kells, Stanford Research Institute, made and mounted the shaped charges. The experiment itself was suggested by Dr. Zwicky (see August, 1957, Astronautics, pages 48–49), and was first tried with German V-2 vehicles in 1947.

capital wire

News highlights from Washington

ADMINISTRATION

• Impact of the "single manager" concept on anti-missile and outer space programs probably won't be revolutionary. Dismayed at first by what seemed an imminent breakup of existing facilities and manpower pools, the services—and industry—have been reassured. What is likely is a tightly-knit group on the Defense Dept. level, with controls running to units that remain administrative adjuncts of the armed services.

Heavy emphasis will be put on elimination of interservice quarreling. Fast and effective use of research and development facilities is the major objective, but there's no question that worsening interservice warfare brought about the single manager concept. And, if this solution doesn't work, Defense Secretary McElroy can be expected to take more drastic action.

• Pentagon also hears that Paul D. Foote, now Asst. Defense Secretary for Research and Engineering on a recess appointment, will withdraw before his nomination—blocked last summer by conflict-of-interest problems—is resubmitted to Senate. By increasing power of Missile Director William Holaday and appointing a Single Manager for anti-missile missiles and space projects, McElroy appears to have subordinated the job held by Foote.

• Defense Secretary McElroy is proving receptive to projects for reconnaissance satellites, rocket-glide vehicles and similar far-reaching concepts. Insiders predict Bell and Lockheed contracts in this field are only a starter.

• AF announced "breakthrough" by exhibiting new space suit that will be worn by pilot of the X-15. With novel back pack containing automatic controls, suit protects against heat or cold, loss of cabin pressurization, failure of plane's oxygen system, and flash fires and wind blast. When X-15 flies some time this year, it's expected to reach 200,000 ft altitude and speeds in excess of 4000 mph.

• Impressed by recent briefings on Nike-Zeus, the Office of the Defense Secretary is prepared to pour more money into the project.

• Army is studying a variety of anti-satellite concepts. One of first papers was in terms of a little "anti-satellite satellite," and was code-named Project Burro. Interception and creating a meteor shower in enemy satellite's orbit are two of the ideas being appraised.

MISSILES

• Production of Thor and Jupiter is expected to accelerate rapidly. Douglas should hit six-a-month rate with Thor by early Spring, while combination of Redstone Arsenal and Chrysler will produce five Jupiters monthly somewhat later in the year.

Chrysler's production line for Redstone may be slowed, but Pentagon considers this a low-priority item and isn't disturbed. Ultimately, all Jupiter production will center in Chrysler's Michigan missile plant, but Redstone Arsenal will have to provide many components for a while.

• Army, vastly encouraged by Defense Secretary McElroy's openmindedness on roles-and-missions problem, sees real hope that limitation of its missiles to 200 mile range will be changed. An improved version of Redstone, with better than 500-mile range, is coming along rapidly, and Army is optimistic about chances of building and operating it. That's real reason for graceful acceptance of production slowdown on present Redstone, necessitated by decision to build Jupiter in quantity.

• Ground handling equipment and well-trained military personnel will be new bottlenecks to plague IRBM program now that Jupiter and Thor have been ordered into production. Army's development work on Jupiter ground handling equipment is unfinished, and rapid procurement of this kind of hardware will be a problem for both missiles.

FACILITIES

• Army and AF are pushing different plans for IRBM bases overseas, even though AF will have over-all control of both Thor and Jupiter units. Army believes Jupiter units can be reasonably mobile, despite problems involving LOX production and pressure fueling of the missile. It's therefore sketching organization of self-contained IRBM unit—cooks to missilemen—than can move periodically and avoid being zeroed-in by enemy.

AF plans for Thor unit are less ambitious, since it expects many of its missiles to be put on existing SAC bases, where housekeeping facilities already exist.

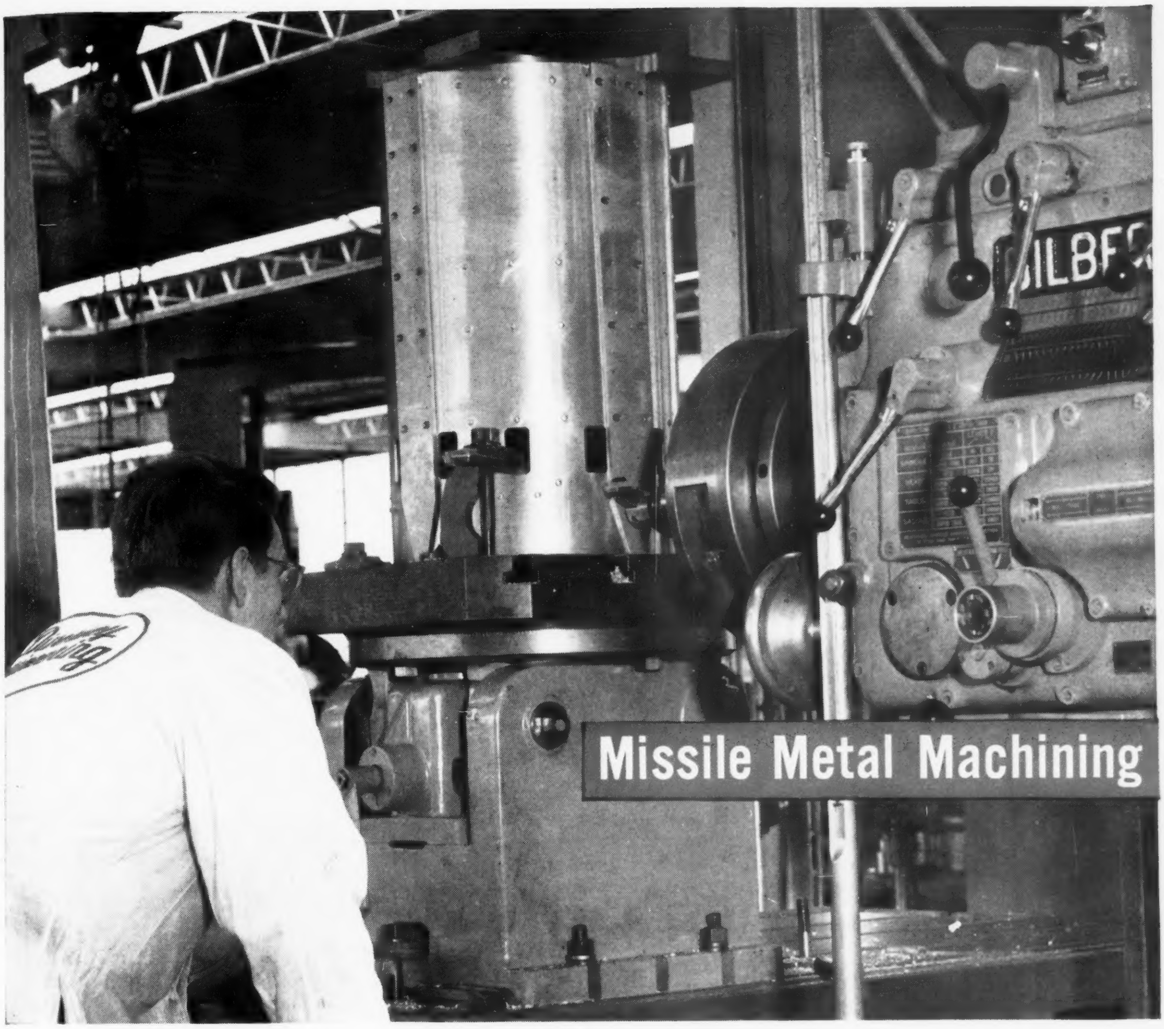
• Accelerated missile program is putting a strain on testing facilities at Cape Canaveral. Result: Development of a fairly long-range test facility on West Coast is likely.

SPENDING

• A substantial hike in defense spending is more likely than ever. While fiscal 1958 expenditures will hover around \$39 billion, Congress will vote enough new money this year to boost the total considerably higher in fiscal '59–60. Pentagon estimates that if all missile, satellite, outer space and orthodox weapon programs go forward, defense spending could hit \$45 billion within three years.

First acknowledgment of the trend may be a request, early in the new session, for a fiscal 1958 supplemental appropriation. It could run to \$500 million.

• When production lines begin to roll, Defense Dept. estimates IRBM's will cost about \$1 million each. Total number being bought isn't firm yet, will depend somewhat on results of NATO conference and decisions on European deployment. Chance that solid propellants will take over IRBM field (solid fuel Thors are reportedly already in an advanced state of development) will also be factor in determining when to cut off production.


Missile Metal Machining

in print

Rocket Power and Space Flight, by G. Harry Stine, Henry Holt & Co., New York, 1957, 182 pp., illustrated. $3.75.

Reviewed by HOWARD S. SEIFERT
Ramo-Wooldridge Corporation

G. Harry Stine, in a style which is vivid but youthfully extravagant, has addressed himself to the hot rod and hi-fi set in their own language to describe the rocket and missile business as he saw it from his vantage point as a test engineer for the Navy at White Sands Proving Ground. As a document for stimulating the interest of young men from 15 to 25, his book succeeds in "cutting the mustard," to borrow the author's phrase.

Mr. Stine was trained as a physicist, and in the first chapter does a reasonably good job of explaining reaction propulsion and nozzle flow in simple terms. Many of the chapters are followed by short addenda which contain tables or equations. There is some question in my mind, however, whether bare definitions, such as those of L* and c* stated at the end of Chapter 1, will be meaningful to a lay reader.

Chapter 2, on hazards, is directed toward the do-it-yourself experimenter. Mr. Stine assumes that boys cannot be prevented from playing with rockets; the best thing to do, therefore, is give them advice on safety. The author is in a good position to do this, as he has carried out a number of his own backyard experiments.

Chapters 3, 4 and 5 discuss solid rockets, liquid rockets and aerodynamics, although not under such prosaic titles. The chapter on liquid rockets, for example, is headed "The Controlled Catastrophe." The author's description of the *uncontrolled* catastrophe to Viking No. 10 (not the famous one which tore loose from its moorings during static test) reminds this reviewer that, if research directors could be persuaded to allow only a few of their shots of rocket failures to be released, a most dramatic film could be assembled. Chapter 4 contains an erroneous statement (p. 60) that the Mach number of a rocket exhaust equals the number of shock diamonds it contains.

Chapter 6, on testing, reliability and telemetering, contains a typical Aerobee count-down which should interest prospective rocket pilots. Chapter 7 describes, in journalistic style, a firing of the Aerobee-Hi sounding rocket not omitting a description of the emergency impact predictors, a roulette wheel and a ouija board.

Chapters 8, 9, 10 and 11 are devoted to satellites, space medicine, the orbiting space station and speculations on planetary travel. They are lively and sufficiently short not to tax readers with a limited attention span. The final chapter is an inspirational appeal to readers of all ages to join the rocket fraternity, and is followed by a useful list of societies, schools and corporations doing work in the field.

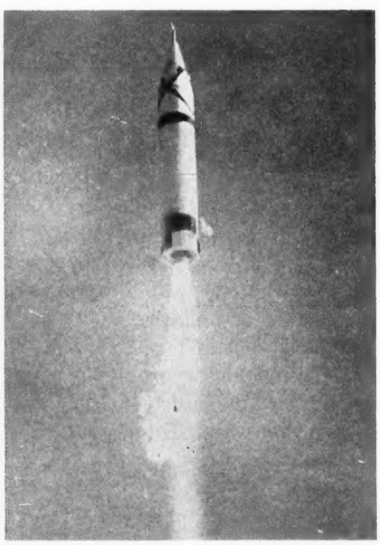
Mr. Stine's book is based on valid experience at White Sands Proving Ground, and his descriptions of experimental procedures have an authentic ring. His technical statements are for the most part physically correct (with the exception noted, and the spellings of "brisance" and "discrete" on pages 22 and 96). I believe he has written a book which can play a unique role in interesting younsters, and which should be placed in their hands. (That is, if they can afford it! It is an interesting commentary on the publishing business that this volume of 182 pages costs just 10 times as much as Mr. Stine's preceding book of 191 pages on satellites.)

Mr. Stine's style is so vivid and hortative (even hyperbolic) that he may be regarded by some as the Billy Graham of rocketry.

BOOK NOTES

An official general history of the U. S. Air Force and its predecessors, prepared by the AF Historical Div. in cooperation with the editors of *Air Force Magazine*, has just been published by D. Van Nostrand Co., Inc. Titled "A History of the U. S. Air Force–1907–1957," the large format volume (288 pages, over 500 illustrations, $6.75) tells the AF story from the birth of the Army air arm just 50 years ago until today, in terms of growth, organization, men, tools and missions down through the years. Missiles get short shrift in the book, only a few pages being devoted to the subject.

The Philosophical Library has just published "Aircraft Annual–1958" (96 pages, illustrated, $6), edited by John W. R. Taylor. The book, published in Great Britain, is made up primarily of "popular" features, apparently reprinted from various publications. However, it does contain a short article on the Atlas and Titan ICBM's by Kenneth Gatland, well-known British rocket authority and writer, as well as a piece on "Russia's Fighting Aircraft," which may prove of interest. **I.H.**



THOR AND JUPITER: Production plans get green light.

IRBM's to Go Into Production

The National Security Council has approved Air Force plans for the production of the Thor IRBM, contingent upon DOD spending schedules. Production of Army's Jupiter IRBM also received official okay. Indication is that council members have seen some rather convincing evidence to back service's claims for missiles.

feedback

Says We're Loaded . . .

Gentlemen:

The American Rocket Society is to be complimented on its new publication, ASTRONAUTICS. The first three issues have been loaded with information—so much that we have made ASTRONAUTICS "must" reading for all of our District Sales offices.

Again may we extend our congratulations to the American Rocket Society for a fine magazine.

C. G. Chisholm
General Sales Manager
Haynes Stellite Co.
Kokomo, Ind.

Wants ARS Section in Europe

Dear Sir:

As a member of the ARS, I am writing you to advance a proposal for the establishment of a new ARS section: ARS Europe.

Though title-wise it may seem contradictory, there appears to be the foundation for a strong and active ARS section here in Europe. As you know, a sizable portion of the militarily operational rocket and missile forces of the U. S. are employed here in Europe. A complete cross section of rocket weaponry is involved . . . (encompassing) the basic fundamentals of the rocket and missile sciences. Thus there are many Americans here who are directly interested in the rocket sciences and who would undoubtedly welcome the opportunity of becoming active ARS members . . .

Of course, the basic consideration for establishing an ARS Europe section would be to forward the goals and principles of ARS. In addition, the ARS would be affording the U. S. a tremendous service by providing the opportunity for Americans here to attain a higher degree of professional knowledge by creating a ready means of exchange of ideas, by stimulating thought processes and by stirring the imagination.

However, please do not think that we in Europe would be on the receiving end only. In time there would be definite contributions to ARS . . . (in the form of) technical papers and papers elaborating on the problems and procedures of groups having the responsibility for the finished military product. This is indeed an area of interest and concern to many in the rocket field . . .

Please give this proposal your considered thought. We need an active ARS section for Americans in Europe.

1st Lt. Richard T. Boverie, USAF
Hq., 587th Tactical Missile Group
APO 130, New York, N. Y.

Lt. Boverie has been given the green light. Meanwhile, any Europeans or Americans stationed in Europe who are interested in his plans for an ARS European section can contact him at the above address—Editor.

Concerned Over Soviet Satellites

Dear Sirs:

I am a Luxembourger, in my first year at the Swiss Federal Institute of Technology.

I was shocked to hear that the Russians had succeeded in launching a second satellite, weighing 508 kg, for I had hoped that the Americans would prove they had a military force second to none. However, the weight of this second satellite proves to the whole world that the Russians are leading in the field of rocketry.

It is almost too late to make up for the lost advantage unless research and development would now be undertaken with the fantastic strength which no other nation but the U. S. can muster. It is vital to assure a free future in a free world, and only the U. S., together with its allies, can do this.

The world is waiting impatiently for the flourishing of American astronautics . . .

Julien Cajot
Bertrange
Luxembourg

The ARS annual meeting in New York last month offers graphic evidence of many solid American accomplishments in the rocket sciences, and indicates every effort is being made to insure the fact that the U. S. remains a leader in the field of astronautics—Editor.

Urges ARS Moon Orbiter

Dear Sirs:

This letter is prompted by the current news concerning Russian rocket developments.

If the reaction of the people I know is typical, most Americans are ready for some bold and drastic action to recoup our position in the space race. Since our government has given no signs of offering leadership to this desire, it seems time to try some other channels.

Because the American Rocket Society seems to be the logical organization, I would like to propose the following idea:

1. That the ARS sponsor a project for orbiting of the moon by an unmanned rocket.
2. That this project be a private, nonsecret, nongovernmental project outside the security program.
3. That this project be implemented financially . . . either (a) as a nonprofit corporation supported by public subcription, or (b) as a corporation selling shares at $10 a share and accepting contributions in smaller amounts.
4. That this project be initiated at the earliest possible moment to take advantage of the current urgency of interest in the subject.

Undoubtedly such a project would be bitterly criticized from within the government. On the other hand, I believe it would receive enthusiastic support from the general public, technical personnel and even from many of the companies currently involved in missile work . . .

I've broached this idea to several acquaintances and have received enthusiastic responses, including pledges of money for the project.

Given leadership and vision, I feel confident that the people of this country could be aroused to support such a project. From the public relations standpoint, it's a natural . . .

Richard E. Upton
6424 Rolf Ave.
Minneapolis 24, Minn.

How do ARS members feel about Mr. Upton's proposal?—Editor.

From Another World?

Sir:

Krafft A. Ehricke mentions several thought-provoking possibilities in his article entitled "The Anthropology of Astronautics" (November 1957, ASTRONAUTICS, page 26) . . .

The article describes the possibility of our coming in contact with other world cultures while engaged in space travel and exploration of other worlds.

Mr. Ehricke's description of future possibilities lends itself to some alternate theories that I would like to suggest:

1. Life on the planet earth could have been established by a specific planetary culture or could have been brought here from another world.

2. Conclusive evidence may exist to demonstrate that our earth culture had already been contacted by another world culture.

Scientific research has established that the planet Mars gives evidence of being older than the planet earth. A theoretical race facing a loss of natural resources could have left the planet and colonized the earth . . .

There are seemingly thousands of small asteroids circling around the sun in an orbit outside that of Mars. It could well be that these asteroids are the remains of a planet older than Mars. We could conjecture that this planet was the original source of life for earth and possibly Mars as well.

What type of evidence would be necessary to demonstrate that our earth culture had been contacted by another world culture? Sources of such evidence would lie in the records of ancient civilizations and in the recorded evidence of modern societies. Interesting examples of such evidence do exist . . .

Of course, such incidents are not authentic enough to demonstrate contact. Such contact would require visual and physical contact by means commonly understood by human beings of this planet. The interesting possibility remains, however, that lack of human sensory ability or scientific instrumentation may prevent the human race from perceiving such theoretical contacts . . .

KENNETH L. LARSON
14447 E. Gale
La Puente, Calif.

Russians Find Ziolkowsky Letters to Goddard, Oberth

Soviet newspapers recently announced the discovery of hitherto unpublished letters written by Konstantin E. Ziolkowsky, the Russian "father of astronautics," to rocket pioneers Robert H. Goddard and Hermann Oberth. Contents of the letters have not as yet been revealed.

X-7 in First Public Showing

The Lockheed X-7 test vehicle was shown publicly for the first time at the recent dedication of a new Air Force reserve center in Los Angeles. The X-7 has been used in the successful flight testing of a large Marquardt Aircraft Co. ramjet engine to be used with an operational missile now in production, and is now being used to test an even more powerful Marquardt ramjet in tests at the AF Missile Development Center.

that's the word, sir...

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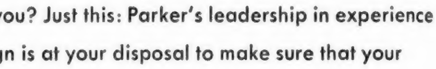


Parker Aircraft Co., Los Angeles 45, Calif. • Cleveland 12, O

(Subsidiary of The Parker Appliance Company)

COVER: *Boeing technicians prepare Bomarc model for placement on sting prior to testing in company's new Mach 4 wind tunnel in Seattle.*

Astronautics

JANUARY 1958

Year of Decision

There can be little doubt that 1958 will be a year of decision for the U. S. in the fields of rocketry and space flight. Decisions made now—this week, this month and in the months to come—will play a major role in assuring national security and in determining whether this country is a leader or a follower in making man's age-old dream of reaching the stars a reality.

In any such decisions, the American Rocket Society and its thousands of individual members will play a leading part. The proposal for a national space flight program drawn up by the ARS Space Flight Committee and announced at the Annual Meeting in New York last month is indicative of just how important the role of the Society has become.

It is indeed a privilege to be called upon to serve the Society in what promises to be one of the most important years in its 27-year history. It is with mingled feelings of pride and humility that we approach the tasks that confront us.

From the standpoint of the Society itself, these tasks are many and arduous. That ARS should continue its spectacular growth of the past few years, that member services should be improved and expanded, that our publications should be enlarged, goes without saying. These steps are vital if the Society is to continue to play an important role in the fields of rocketry and astronautics.

Equally important, however, are the tasks which face us as a Society. Of paramount importance are such efforts as working with our educational institutions to assure the kind of undergraduate and graduate training necessary to provide an unending flow of top-notch engineers for our national ballistic missile and space flight programs; focusing attention on the need for additional research in the many basic and applied sciences related to astronautics; helping to resolve the present conflict between military and commercial interests in space flight; and awakening the public to the many commercial possibilities in such flight.

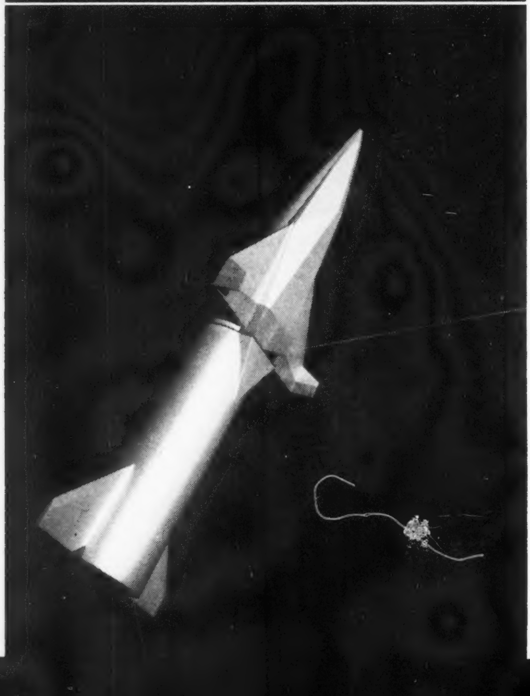
In all these tasks, individual ARS members can and should play an important role. A bigger and better Society is a "must" if this country is to remain in the forefront in the conquest of space.

How effective our efforts toward this end are will be determined largely by your own contribution in the months that lie ahead.

George P. Sutton
President, American Rocket Society

ARS urges national space flight program

Space Flight Committee proposal for establishment of Astronautical Research and Development Agency to take over long-term planning is now under study. . .Venus and Mars probes seen within five years, and two-way manned flights to moon, including landing, within 20 years



THE AMERICAN ROCKET SOCIETY has submitted to President Eisenhower a full-scale report calling for immediate initiation of a long-term national space flight program, to be administered by a new independent government agency with broad powers in this area.

The report, drawn up by the ARS Space Flight Committee, headed by Krafft A. Ehricke of Convair-Astronautics, and accompanied by a covering letter over the signature of Comdr. Robert C. Truax (USN), outgoing ARS President, has achieved wide circulation among government agencies and is being given serious consideration.

Copies are now in the hands of members of the President's Scientific Advisory Committee, the National Security Council and the Policy Planning Staff of the State Department, as well as top Defense Department officials and congressional leaders.

The complete text of the report, as well as the covering letter, begins on page 21.

Written Before Sputnik I Firing

The report, written before Sputnik I was fired, notes that, while the military aspects of space flight have been carefully considered, many important scientific, commercial and politico-military applications of even greater long-range significance have been overlooked. Moreover, no government agency exists with powers broad enough to plan a program of the type required, and existing space flight efforts are being hampered by the lack of such an agency.

As a result, immediate initiation of a national space flight program and establishment of an over-

Some typical space vehicles which might be used in national astronautics program are shown on these two pages. Designed by Krafft Ehricke, they are (top) an unmanned three-stage automatic supply ship and (below) a manned three-stage supply vehicle.

all supervisory agency, similar to the Atomic Energy Commission or the National Advisory Committee for Aeronautics, are urgently required. Major prerequisites to the success of these measures, the report points out, would be adequate financing and the formulation of a clear-cut agency broad enough to include all but the strictly military applications of space flight.

Toward this end, the report recommends a six-step space flight program which the current state of the art would make possible even without any major technological breakthroughs in the next 20 years. These are:

1. Orbital vehicles with payloads in the order of thousands of pounds within five years.
2. Payloads of 100 to several hundred pounds placed on or about the moon within five to 10 years.
3. Payloads of several hundred pounds as far out as the orbits of the nearer planets within five to 10 years.
4. Manned orbital vehicles and manned space flight between any two points on the earth's surface within 10 years.
5. Manned flights around the moon in 15 years.
6. Manned two-way moon flights, including landing, within 20 years.

Utilization of Present State of the Art

These goals are in accordance with the philosophy of the report, which stresses concentration on those phases of space flight which have immediate utility or a real possibility of utility; which can employ the available state of the art, summarized in an appendix to the report, to the greatest extent, and which can be realized with modest extrapolation of existing techniques; and to initiate on a modest scale the research necessary to develop the specific astronautical technology that will make long-range goals feasible.

Space flight, it is pointed out, cannot be regarded simply as an extrapolation of missile technology. Nonetheless, certain of the goals of both missile technology and astronautics are similar, and astronautics can take advantage of the large-scale research and development activities, skilled manpower and vast expenditures currently available to the ballistic missile program.

The immediate purposes of this separate space flight program would be: First, to increase the dividend from current military expenditures by

Even farther in the future are these three ships. Starting at bottom, a four-man observational satellite, a manned lunar reconnaissance vehicle, and a manned nuclear interplanetary vehicle.

Robert C. Truax
Outgoing ARS President
SUBMITTED PROPOSAL TO PRESIDENT

Krafft A. Ehricke
Chairman, ARS Space Flight Committee
HEADED GROUP WHICH FORMULATED PROGRAM

applying them in astronautical projects; second, to apply the best of the present and future states of the art to astronautical ends; third, to improve the state of the art in those areas not covered by existing military requirements; and, fourth, to develop a true astronautical technology, separate and apart from missile technology.

The report recommends that, in the absence of an existing agency which has all the necessary capabilities, a new agency, temporarily referred to as the Astronautical Research and Development Agency (ARDA), be established and charged with formulation and execution of this program.

The agency would have space flight as its sole mission, would be staffed and organized for this one purpose, and would have to justify its program only to the President and Congress.

Primary control of ARDA, the report states, should rest in the hands of persons with experience in the development of rocket vehicles, although the State Department, as well as the scientific community and the general public, would also be represented on the agency.

The agency's mission would include the development of astronautical equipment and the conducting of unmanned, as well as manned, exploratory space operations. Missions cognizance should be provided over all but strictly military projects. Its responsibility would be "to develop the science of astronautics, to establish man's capability of conducting operations in space, and to derive new benefits. . .from such capability for the good of this nation and of all mankind."

Would Be a Management Agency

ARDA would not compete with industry, nor with the Armed Forces. It would basically be a management agency operating by contract to industry, research organizations, etc.; conducting theoretical studies and operating its own research laboratories when necessary, and evaluating scientific information about space flight; supporting Armed Forces R&D activities not only by making its own information available, but by training personnel, helping in tracking operations, etc.; and serving the various branches of the government in an advisory capacity. It would also represent the U. S. in astronautical projects carried out on an international basis.

Members of the ARS Flight Committee which drew up the report, in addition to Krafft Ehricke, are: Karel J. Bossart, Convair-Astronautics; George H. Clement, The Rand Corp.; Maj. George D. Colchagoff, Headquarters, ARDC; Col. William O. Davis, Wright-Patterson AFB; Frederick C. Durant III, Avco Mfg. Corp.; Andrew G. Haley, Haley, Wollenberg & Kenehan; Richard W. Porter, General Electric Co.; Darrell C. Romick, Goodyear Aircraft Corp.; Milton W. Rosen, Naval Research Laboratory; Alexander Satin, Lockheed Aircraft Corp.; S. Fred Singer, University of Maryland; Kurt R. Stehling, Naval Research Laboratory; Hubertus Strughold, Randolph AFB; and Wernher von Braun, Army Ballistic Missile Agency.

A NATIONAL SPACE FLIGHT PROGRAM

A REPORT BY THE SPACE FLIGHT TECHNICAL COMMITTEE OF THE AMERICAN ROCKET SOCIETY

August 23, 1957
Revised October 10, 1957

PURPOSE OF REPORT

It is the considered opinion of the AMERICAN ROCKET SOCIETY that rather extensive flight through space is practicable, useful and economically feasible in the immediate future. It is the purpose of this report to propose a program and organization to derive maximum benefit from this new capability. The program should not be limited by restriction to immediate military utility, but should rather seek its justification in the necessity of keeping this nation in the forefront of those who will explore the new environment about to be entered by man. This is a long-term mission of grave national and international responsibility. The managing organization should, therefore, not be a lone association of operating activities and advisory committees such as is carrying on the present Vanguard program, but a permanent executive organization, responsible to the Congress and equipped with full authority to carry out its decisions.

Although this report is of an unclassified nature, it has been prepared by individuals having full access to all necessary information in their daily work on the nation's guided missile program. The report is rendered in full awareness of the current programs and state of the art.

American Rocket Society, Inc.

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Washington, D. C.

October 17th, 1957

The President
The White House
Washington, D. C.

Dear Mr. President:

The enclosed report of the Space Flight Committee of the American Rocket Society is respectfully submitted for your attention.

It documents the need for a continuous national Space Flight Program, and for an organization to carry it out. Also enclosed is information regarding the American Rocket Society, from which our competency to make such a recommendation may be judged.

These recommendations in no way represent a stopgap answer to the satellite of the USSR. Indeed the report was drafted prior to the Russian announcement. We do feel, however, that the recommendations represent a course of action, which, if carried out, will insure the eventual superiority of the United States in this new field. Our Society feels that any less forthright action will not be adequate to overtake the Russian lead.

Although this report is of an unclassified nature, it has been prepared by individuals having full access to all necessary information in their daily work on the nation's guided missile program. The report is rendered in full awareness of the current stage-of-the-art. We earnestly request your consideration of the ideas outlined.

Our Society represents a direct channel to the best qualified talent in this country in the missile and space flight field. We are pleased to offer our further services in any manner that might be helpful. In particular we would like to discuss further, with you or whomever you designate, the specific proposal advanced in this report.

Respectfully yours,

Robert C. Truax

ROBERT C. TRUAX
President
American Rocket Society

SUMMARY

The development of rocket propulsion and related techniques during the last 25 years has brought us to the point where a totally new type of transportation is attainable in the immediate future. These developments promise the ability to navigate through a new medium—the region of empty space outside our terrestrial atmosphere. This new ability, if properly exploited, may be used to achieve many unusual and far-reaching results, some foreseeable, some predictable only by analogy with past experience in other spheres.

Historically, major developments in transportation have exercised a revolutionary influence upon human society. It is also historically true, although less well recognized now, that the full importance of these developments was seldom appreciated in the beginning. Manned, powered flight was a reality for $5^1/_2$ years in the land of its birth before the first military airplane was procured. Even at that date there was no clear idea of the military utility of this new vehicle.

Military application of space vehicles has fared much better to date. The first true space rocket, the German V-2, was an operational weapon, and today our highest priority goes to the development of more sophisticated space weapons, the intermediate and intercontinental ballistic missiles.

The strictly military aspects of space flight are probably receiving adequate support at the present time. However, there are many scientific, commercial and politico-military applications of even greater long-range importance, which, in the opinion of the committee, are being neglected. These are discussed more fully in the body of this report. Indeed, there is no agency within the government which has a mission sufficiently broad to encompass a program such as is felt to be required. Existing effort is being hampered by this lack of an agency having appropriate responsibility and authority.

The recommendations of the committee are twofold: First, that a national space flight program be initiated; and, second, that an agency

having independent status similar to that of the Atomic Energy Commission or the National Advisory Committee for Aeronautics be created to manage this program. Prerequisite to the success of these measures are considered to be adequate financing and sufficient breadth of mission to include all but strictly military applications of space flight techniques.

It is also considered important that space flight be considered as a new transportation technique capable of serving many purposes. As such, primary control of the new agency should be vested in persons having experience in the development of rocket vehicles, rather than with any special class of user. Potential users, however, should be accorded an adequate voice in the formulation and execution of the program.

The impact of space flight on the minds of men is too great to permit the challenge to be met with half-hearted measures. *Astronautics* can no longer be considered as an appendage of the Science of *Aeronautics.* A unified, long-range program, consistently prosecuted and soundly managed, is the only answer that will insure our ultimate superiority.

1. FEASIBILITY AND OVER-ALL IMPORTANCE

1.1 *Feasibility and Immediacy.* Recent advances in rocket and allied technology have brought us to the point where an age-old dream of man, flight through outer space, can be realized.

Space flight, or astronautics, has as its key problem the development of rocket vehicles capable of tremendous speeds. Some 3600 mph are required for a ballistic missile to travel a mere 200 miles. At 18,000 mph, a craft can leave the gravity field of the earth forever and travel to other celestial bodies.

Significantly, an intercontinental ballistic missile must possess a speed only 10 per cent less than that required to orbit. Certainly we must presume success for our ICBM program in the not-too-distant future. The implications of this program to the over-all feasibility of space flight can not be overemphasized. Although it is possible to develop other vehicles to provide the velocity required for astronautical purposes (e.g., Vanguard), the payload capabilities of the ICBM vehicles, their continued production for military purposes and the broad base of support which they are creating form the prime basis for the assertion that we are truly on the threshhold of space. Indeed it is primarily the status of the ICBM program which gives rise to this report and the call for action now.

Using the ICBM as a booster for other smaller rockets, it is a comparatively easy matter to put very large payloads on orbit around the earth or to send smaller rockets to or around the moon. The successful development of an intercontinental ballistic missile will bring such ventures from the realm of theoretical feasibility to that of practical immediate attainability. While still expensive in total dollars, they become economically feasible in terms of probable return.

1.2 *General Scope of Recommended Program.* It is considered particularly important from the point of over-all economy that space flight development be organized for the long pull, rather than on a single project basis. With Project Vanguard, we have already begun a fairly expensive effort without an adequate plan or management organization. Future efforts must not be allowed to spawn haphazardly or chaos will result. A long-range integrated program would permit projects to be mutually supporting in terms both of knowledge to be gained and equipment to be developed. It would permit fullest advantage to be taken of military developments. It is for this reason that this report does not attempt to define the cost of all the foreseeable projects, but only to list the typical examples and estimate a general level of expenditure that would permit realization of significant goals on a realistic time schedule.

From a careful balancing of desirable goals, technical tasks to be performed, support from military programs and reasonable burden to the taxpayer, it is the opinion of the Space Flight Committee that we could expect results such as the following:

(1) Orbital vehicles with payloads in the order of thousands of pounds within five years. (Scientific, communications, weather or politico-military missions.)

(2) Payloads of 100 to several hundred pounds placed on or around the moon within five to 10 years. (Scientific missions)

(3) Payloads of several hundred pounds into interplanetary space as far out as the orbits of Venus and Mars within five to 10 years. (Scientific missions)

(4) Manned orbital vehicles within 10 years. (This capability would include manned space flight between any two points on the earth's surface. Scientific, communications, weather and politico-military missions.)

(5) Manned flight around the moon in 15 years. (Scientific missions)

(6) Manned two-way flight to the moon, including landing, within 20 years. (Scientific missions.)

This schedule is based on the assumption that no major breakthroughs in propulsion would occur. A survey of the existing state of the art on which this prediction is based is contained in the appendix.

1.3 *Philosophy and Purpose of the Program.* Many times, especially since World War II, programs for the development of space flight and associated cost estimates have been submitted. In practically all cases the authors reached too far into the future, underestimated practical difficulties and were optimistic in regard to time and cost factors. The philosophy adopted in this report is that we should: (1) Concentrate on the more immediate phases (a) which have utility or indicate a real possibility for utility in the immediate future, (b) which can utilize the available state of the art to the greatest possible extent, and (c) which can be realized with modest extrapolation of existing techniques; and (2) to initiate on a modest scale the research work to develop the technology that will make the long-range goals eventually attainable.

It is well recognized that space flight can not be regarded simply as an extrapolation of missile technology. Astronautics must, and will in time, develop its own "style." However, in order to do this, it must first get started. As it grows, expands, and acquires more utility, the possibilities for developing a specifically astronautical technology will improve constantly.

The most important task right now is to maintain and augment the momentum gathered by the success of high-altitude research and by the Vanguard project.

At the present time—and probably for quite a number of years to come—research and development facilities, skilled manpower and available funds will be very tight, because of the demands of military missile development. Thus, unless this situation changes, it cannot be expected that a comparable capacity in these three basic ingredients of progress will be available for space flight programs. Therefore, until such change, astronautics must largely be based on missile technology. This may not correspond to the "best" approach to space flight from the engineering as well as operational point of view, but it is the only approach available, and nevertheless quite a good one.

Astronautics is still so much in its infancy that its realistic goals for the present are very much like those of present missile development. This is particularly true in the field of large boosters, hypersonic gliders, space medicine, electronics, computers, in-

strumentation, test facilities, propellant research, nuclear propulsion research, free radical research, plasma flow and ion propulsion research, to name only some areas of activity.

Even if all this would be placed tomorrow under the command of a "space czar," bent only on developing interplanetary flight, most of the present programs could be continued unchanged. In this sense, we do have a space flight development program. It is recognized that astronautics never had a greater chance to overcome the initial hurdles, and materialize in the wake of nonastronautical utilities, than it has today. What, then, is the purpose of a separate space flight development program?

The immediate purpose of such a program is:

(a) To increase the dividend from the current tremendous expenditures for ballistic missiles by applying them, through judicious adaptation, to astronautical purposes.

(b) To apply the best of the state of the art *systematically* to the development of astronautical utilities, without bias relative to source of data or equipment.

(c) To improve the state of the art in those areas not covered by existing missile requirements in order to increase space flight capabilities.

(d) To initiate, coordinate or support advanced research for space flight, in order to promote the development of an astronautical technology which eventually will be emancipated from missile technology and whose progress will no longer necessarily be incident to progress in missile technology.

This program thus complements military developments for the benefit of this country.

It does not duplicate activities for which defense money is spent.

It is capable of furthering the prestige of the United States by putting us in the forefront in a pioneering field that has tremendous popular appeal.

It can do this at a modest cost which is far less than the benefit derived, because its effort can be skillfully compounded with the defense effort on the basis of technical performance alone, without bias as regards service prestige or rivalries.

It does prepare this country's government to enter international agreements and activities pertaining to astronautics in a well-planned manner and in a leading position.

A detailed technical plan of action would be worked out by the agency responsible for the space flight program.

2. UTILITY

In considering the initiation of any program of the magnitude contemplated here, the question of utility naturally arises. This utility must be established for the aggregate benefit of the country at its full price, or, when related to the individual taxpayer, at a level comparable to his own contribution.

Benefits may be expected from the program in a number of categories. There will be increased national security as a direct result of the devices produced, and as a result of the type of industry developed and supported. There will be military and industrial benefits indirectly, as a result of the new discoveries made both in the development of the vehicles and their equipment, and in their use for scientific purposes.

For the individual, the largest direct benefit will be a sense of participation in a great adventure, and a new breadth of understanding resulting from a better understanding of the universe around him. This popular interest need reach a level comparable to a couple of cartons of cigarettes a year in order to completely justify the program, regardless of other dividends.

2.1 *Immediate Aspects.* For the purpose of this report, the term "immediate aspects" is taken to mean a time period in which the following programs have been advanced to the state of practical accomplishments:

I. Instrumental satellites for distances as far as the 24-hr orbit, for payloads up to the order of 2000 lb for long operational life, with long or indefinite power supply and with recoverability (where needed).

II. Cislunar and lunar instrumented probes.

III. Instrumented comets for interplanetary, planetary and solar research in the region from Venusian space to Martian space.

IV. Manned hypersonic gliders capable of descent from space.

V. Small inhabitable Earth satellites of four- to perhaps 10-person capacity.

VI. Manned lunar operations (circumnavigation, landing).

Roughly, the first three programs could reach the state of practical operation in the 1958–1970 period, the last three programs in the 1970–1983 period. Thus, the term "immediate" is meant here to cover about the next 25 years.

The first three programs deal with unmanned space vehicles, exploiting the possibility of space research as far as it is possible for earth surface-based operations during this period.

The last three programs introduce manned space flight. The principal utility lies with the inhabitable satellites (they do not necessarily have to be permanently inhabited), but their use, of course, requires that personnel can get to the satellite and back. To draw the maximum benefit from the inhabitability of satellites, however, reasonably economic means of ascent and reasonably nonhazardous means of descent must be available. For this reason, it is felt that programs IV and V should aim at nuclear propulsion, booster recovery, and combined thrust-brake and aerodynamic descent.

A further discussion of these programs will follow in Part III. Presently, the utility of such developments will be surveyed with respect to the following areas, arranged alphabetically:

1. Agriculture
2. Communication
3. Industry
4. Medicine
5. Politico-Military
6. Natural Sciences

Many of the utilities mentioned below are not novel. They are listed here to provide a complete picture as far as present anticipation of utilities is concerned.

1. *Agriculture.* By surveying earth from space, long-range and short-range weather prediction becomes more accurate on a continental as well as local basis. Organized, satellite-based weather service would result in great benefits to the agriculture, and therewith to the economy, of all nations.

2. *Communications.* Instrumented satellites, especially when they are at great altitudes (4000 to 8000 miles), can serve as passive intercontinental and transcontinental communication links for radio and television transmission. Manned satellites can in addition assume surveillance of terrestrial operations in remote areas and the servicing of ships, expeditions, etc., with information and advice.

3. *Industry.* The environmental conditions on satellites offer four outstanding features: Vacuum, extremely low temperatures and large temperature differences, intense radiation from infrared to x-rays, and weightlessness. Suitable orbit position can provide a maximum of sunshine which can easily and reliably be used for high temperature processes. Conversely, behind a solar and terrestrial radiation shield, extremely low temperatures can be maintained indefinitely for the storage of liquid gases and radicals, and for maintaining processes involving superconductors. Vacuum can be used for welding or soldering; various gas atmospheres can be established in special confinements for manufacturing processes. The industrial value of satellites may lie in the production of small parts for electronic products or instrumentation, for quantity production and

storage of radicals and for other purposes—possibly even for the manufacturing of completely new products.

4. *Medicine*. The aforementioned environmental conditions, particular to satellites or space vehicles, may equally benefit medical sciences. One field which is frequently mentioned is, of course, space-medical and space-biological research. Yet practical medicine may find equal benefits in many unsuspected ways. Weightlessness is normally considered a nuisance. It may, however, be of advantage in cases of heart disease, other organic disturbances, bone diseases and perhaps for surgery in certain aspects. Low-temperature conditions, existing simultaneously with weightlessness, could be found useful in some medical applications. Controlled local or overall irradiation by the sun in space may furnish new therapies against cancer, skin diseases, etc. Apparently, not enough thought has been given so far to the possibilities of satellite therapy and satellite surgery to appraise its potential merits reliably.

In considering Points 3 and 4, it becomes particularly apparent that these utilities depend decisively on the success of Programs IV and V.

5. *Politico-Military*. The immediate politico-military utility is perhaps most apparent, and, by comparison, most readily realizable. It is, for the time being, also the most important utility as far as the means for actual accomplishment are concerned. The prestige value of an advanced position in space flight development has been mentioned. This factor is particularly important during periods of "cold war," where prestige is frequently more important than force in international negotiations. The leading military powers can ill afford to neglect the potential of hypersonic flight and satellite operations. *Chemospheric superiority* implies the successful operation of hypersonic gliders for bombing and reconnaissance. *Ionospheric superiority* means the capability of operating satelloids and satellites for reconnaissance purposes. Finally, exospheric and free space operations, up to altitudes of several thousand miles, are of potential politico-military usefulness because of the increasing terrestrial area which can be kept under surveillance simultaneously. Concern with such possibilities has the added importance of being a necessary prerequisite for outguessing others and developing necessary countermeasures.

In a situation where an uneasy disarmament condition exists, a space flight development program maintains a foundation in industry and technology for the rapid rebuilding of modern military power.

6. *Natural Sciences*. The spectacular scientific utility of instrumental earth satellites is too well recognized to be iterated here in detail. To the geophysical, geodetical and astrophysical benefits, more advanced TV stations will add meteorological and astronomical (observational) research possibilities unequaled on the earth's surface.

Cislunar and lunar probes will extend research on cosmic radiation, meteoritic dust and the geomagnetic field far out into space and will introduce selenological research as well:

(a) by nonoptical measurements in the vicinity of the moon, such as search for selenomagnetic field, for aurora from a very tenous atmosphere (if any), for emanation of corpuscular or electromagnetic radiation, due to surface radioactivity or secondary radiation from cosmic radiation, detectable only at comparatively close distance;

(b) by optical observation of the lunar surface from close distance; and

(c) by impact probing to investigate the nature and condition of lunar soil.

Artificial comets extend the investigation of meteoritic matter into interplanetary space, measure the characteristics and explore the dynamics of interplanetary plasma, of the existence, and stability of magnetic fields in connection with plasma jets from sunspots and for improved understanding of the transfer mechanism governing solar corpuscular radiation. The exact value (up to six digits) of one astronomical unit, of the combined earth-moon mass, of the moon's distance and of the earth's orbit, are yet not known, but are of fundamental scientific and astronautical significance. The mass of Venus can be determined more accurately by measuring the perturbation of the comet in the course of a close encounter with Venus. The attenuation of various radar frequencies by the atmosphere of Venus can be used to measure the content of water in it, the form in which the water is present and the content of solid particles (if any). Thermonuclear probes exploded in the Venusian and Martian atmosphere will determine which elements these atmospheres contain. Many more research programs can be added to this list.

2.2 *Long-Range Aspects*. Many inventions, discoveries or developments with a potential for broadening and enriching human life did not appear impressive or significant at all at the time of their disclosure, because in the then-existing framework of human activities they had no utility, or because there was inadequate vision to appreciate the full consequences. Most innovations have no absolute utility per se, but must be appraised in the context of the civilization by which or for which they are created. As expressions of skill, they rely on the state of the art. Their utility is measured by the needs of their age. Yet by their very existence they help advance or change human civilization. In time they become increasingly indispensable and become a source of further innovations. The explorations of Columbus were justified in prospect by a "short route" to the Indies. They were justified in the terms of the times by Inca and Aztec gold, a wholly unforeseen dividend. Today both of these short-term goals are seen to be minuscule as to ultimate result.

Space flight makes no exception to the general rule. It is not realistic to sit back and wait for the utility of space flight to be "proved" to everybody's satisfaction (if this were possible at all), because this can not be done without the benefit of the knowledge to be gained by space explorations. The development process has to start somewhere, and an initial "down payment" must be made. Moreover, space flight in all its foreseen and unforeseen manifestations is a long development process which spans the activity of generations. Therefore, it is futile to try to ascertain utility of long-range space flight in terms of the present civilization and its needs alone.

1. *Culturally and sociologically* space flight encourages closer ties among nations. Just as the earth satellite provides measurements of planetary character not obtainable otherwise, so will space flight tend to stress the fundamentally unifying characteristics of man over the local anomalies of customs, history and place in which he is born. When these anomalies have lost their devastating capability of arousing misunderstanding, distrust, hatred and even war among peoples, without, however, losing their ability to contribute to the local color and individuality of human culture, the degree of freedom and consequently the richness of human life will have been increased immeasurably.

In fostering such development, space flight is likely to contribute indirectly more to material and spiritual improvements in the living standards all over this planet than any single economic or social measure. It brings this about simply by creating gradually a more intense feeling of belonging to the same planetary community, which provides the necessary conditions for greater economic security, for the profitableness of distributing wealth to increase the living standard of all, and for greater effectiveness of social measures aimed at raising the dignity, as well as the responsibility, of man.

Such improvements, in turn, will not only increase the utility of space flight in the wake of higher standards of living, but will unlock creative forces in all facets of human civilization. These cascading consequences, whose potential exceeds our imagination, just as the consequences of Columbus' discovery exceeded his expectations, may well be among the most important contributions of space flight to the future of mankind as a whole.

2. *Politically*, space flight can not help but make still more apparent the impracticality of war as a means of solving differences between nations. Indeed, the technical and scientific standards required for successfully coping with the problems of interplanetary operations are so high that, if these capabilities were applied with hostile intentions to the narrow confinements of one planet, the prospect of mutual annihilation would become even more likely than it is already. This aspect may be regarded as being of little practical importance, indicating nothing but a still higher degree of "over-killing" participants and bystanders alike, since an all-out thermonuclear war with present means already seems to spell all-around annihilation.

The fact remains, however, that by no realistic standard of reasoning can space flight have any other effect but urging saner alternatives to the classical *ultima ratio* of international politics. In this respect the political effects of space flight will tend to support the cultural implications outlined before.

3. *The economic utility* of more extended space operations is not at all obvious in specific or even more general form at the present time (i.e., in the framework of our present civilization). However, it cannot be denied that the *scientific value* of such operations will be very great. Since there has been little or no scientific knowledge gained in the history of mankind which did not develop practical utility at some later time, the same can safely be assumed to be true for space flight. Practical utilities from scientific knowledge are being developed faster in our civilization than ever before. The probability of yet unexpected economic rewards from space flight can therefore not be discarded. This argument may appear rather vague. However, as emphasized before, this report does not attempt to urge the need for a space flight program on the basis of possible economic utility of interplanetary operations.

The practical worthwhileness of operations on the moon or on our neighboring planets or their moons can be decided only *after* the necessary facts are known. It is important to gain this knowledge so that appropriate decisions as to future action can be made. The very lack of this knowledge is itself an important fact in undertaking space flight.

There is a final factor common to both short- and long-term aspects of space flight that is not subject to the previous type of rational justification. This is the ultimate reason, leading all the others—the undoubted fact that, because of human curiosity and zest for adventure, people simply *want* to explore this new frontier. It is a fundamental urge as elemental as the desire for material comfort or bodily security.

Whether one looks at the long-range or at the more immediate prospects, potentials and utilities of space flight, one finds the prospect most intriguing, the potential breathtaking and the utilities far from imaginary. The interest of the public in the potential of space flight has grown enormously in recent years. This interest may indeed provide the momentum needed to broaden and perpetuate this country's astronautical activities far beyond the present Vanguard project.

3. PROGRAM MANAGEMENT

3.1 *Recommended Organization and Mission.* If it is agreed that a space flight development program looking beyond the purely military applications (i.e., ballistic missiles) is desirable, it follows that there must be an organization charged with the formulation and execution of this program. Two courses of action are possible: Either the mission of some existing agency must be expanded to include astronautics, or a new agency must be created to serve the purpose.

Although certain existing agencies, notably within the armed services, have considerable competence in one or more phases of space flight technique, none contains all the capabilities necessary. Rather great augmentation of existing staffs would be required, as well as alteration of organizational structure.

While this first course of action would provide a cognizant agency, there are two inherent and, it is believed, fatal defects. Firstly, since there are a number of agencies of comparable qualifications (i.e., the Naval Research Laboratory, The Army Ballistic Missile Agency, the Air Force Ballistic Missile Division), selection of any one would be likely to intensify interservice friction.

A second and more important objection is that a new mission assigned to an existing agency would be required to continuously compete with the more traditional mission. Since existing organizations are staffed largely with persons having special experience and interest in the older missions, the new astronautics mission might be expected to receive only marginal support.

For these reasons, it is strongly recommended that a new independent agency, on the same level as the National Advisory Committee for Aeronautics or the Atomic Energy Commission, be created to plan and manage the astronautics program. This agency would have space flight as its sole mission, it could be staffed and organized for this one purpose, and it would have to justify its program only to the President and the Congress.

An appropriate name would be the Astronautical Research and Development Agency (ARDA). The mission of this agency should include both the development of equipment and the conducting of exploratory space operations, unmanned as well as manned. Missions cognizance should be provided over all except strictly military projects.

If the scientific phases of the National Space Flight Program were carried out in a spirit of international cooperation, the program would have a tendency to lessen world tension while maintaining and furthering an industry and technology of vital importance in the case of national emergency.

The need for an independent organization is amply illustrated by the difficulties being encountered in managing the Vanguard satellite project through the present complicated set of advisory committees and executive agents. The extra-military nature of the program further emphasized the need for sufficient breadth of jurisdiction. It is unrealistic to believe that future, more sophisticated and complex programs can be run successfully and economically in such a makeshift manner.

The organization should allow representation by the following agencies:

The general public
The State Department
The Central Intelligence Agency
The Department of Defense
The Department of Commerce
The Scientific Community

The mission of ARDA can be defined as follows:

The responsibility of ARDA is to develop the science of astronautics, to establish man's capability of conducting operations in space, and to derive new benefits and utilities from such capability for the good of this nation and of all mankind. Specifically:

(a) To derive additional utility from present missile developments by applying the existing state of the art to the development of astronautics, and to manage those applications of space

technology not wholly of a military nature.

(b) To conduct research in earth-moon space as well as in interplanetary space with the purpose of advancing the natural sciences and to improve man's understanding of his cosmic environment.

(c) To search out and utilize new potential benefits from space operations or research in space such as may pertain to agriculture, communication, transportation, medicine or other fields of human endeavor.

(d) To improve the state of the art of astronautics, as realized on the basis of missile developments, and to do advanced research for space flight, in order to promote the development of an astronautical technology and assure this country's leadership in space.

3.2 *Operating Principles.* ARDA would not compete with industry. It represents, basically, a management organization, and its various departments serve this purpose primarily. ARDA would operate by contract to industry, to research organizations, airlines or steamship companies as it may become necessary in the course of establishing and maintaining ground stations and airborne stations or in organizing salvaging operations. ARDA would conduct theoretical studies, maintain small research laboratories where necessary, and would evaluate scientific information gained from its activities in space. ARDA would coordinate services such as may be derived from commercial satellites, but it would subcontract the operation and, when possible, maintenance of such stations as soon as they operate on a routine basis.

ARDA will support research and development by the Armed Services in making the results of its own progress and new knowledge gained by such research available to them, and by training personnel, supporting tracking operations, etc., where necessary. ARDA serves the various branches of the Government, particularly the State Department, in an advisory capacity. In the case of joint astronautic endeavors on an international basis, ARDA will be the responsible technical and scientific agency for the United States.

4. THE NEED FOR ACTION

The purpose of this report is to propose a program for space flight and a managing agency, because the Space Flight Technical Committee is fully cognizant of the urgency with which action is needed now.

The development of large and powerful missiles approaches maturity. Satellites are announced and planned by at least two countries, the United States and Russia, within a year or two.

As the door to space is opened, it becomes a generally recognized need for this country not to fall behind in the exploration of space and the development of space operations. There is, however, at present, no government agency established and officially charged with the responsibility of astronautic research and development. This country can not afford to go about this task in a haphazard, casual and unorganized manner. As in the case of NACA, the NBS and the AEC, organizational preparations and long-range planning commensurate with the magnitude of the task and the importance of the stakes involved, must be made. *The time to take action is now.*

Submitted to the President and the Board of Directors of the American Rocket Society, Inc. by the Space Flight Technical Committee of the ARS.

K. A. Ehricke, Chairman

APPENDIX—*State of The Art*

Although the state of the art is apparent from the progress of the missile (particularly the ICBM) program, it is useful to examine this subject in greater detail. This will be done according to the following categories.

1. Propulsion
2. Structure
3. Guidance
4. Re-entry
5. Instrumentation
6. Power Supply
7. Ground Test Facilities
8. Launching Sites
9. Tracking and Communication
10. Supporting Industry and Research
11. Advanced Research
12. Space Biology
13. Systems Development Management
14. National and International Law

It is obvious that, in an unclassified report such as this, only a general survey, based on published facts, can be offered. However, we believe that these facts offer strong evidence of the readiness of our nation to deal seriously with the problem of a coordinated space flight development program and to establish the necessary means for exerting a consistent effort in formulating, managing and realizing such a program.

1. Propulsion. The transition from water-diluted alcohol to hydrocarbon fuels used with oxygen has been successfully completed during the past decade. At the same time, combustion chamber pressure has been doubled and tripled, compared to World War II rocket motors, and great improvements in propellant injection and mixing have been made. These advances have resulted in an increase in standard specific impulse by 20 to 30 per cent over standard values at the end of World War II. Engines for very large thrust, in excess of 100,000 lb, have been developed and are tested on a routine basis. The problem of operating a multi-engine propulsion system has also been worked out, such as in the experimental rocket airplanes and in more advanced missiles. New, more potent fuels and oxidizers are presently under investigation and are tested in rocket engines. High performance turbopumps and feeding systems exist for large rocket motors.

Liquid propellant rocket engines of still higher specific impulse will emerge from present research and development for practical use within the next four to seven years. The Vanguard satellite vehicle is using typical high-performance liquid propellants, developed in the recent past, in its first two stages, namely, liquid oxygen-hydrocarbon and white fuming nitric acid-dimethylhydrazine.

In the field of solid propellants, great strides have been made regarding the performance and size of solid propellant motors. The general field of solid propellants has experienced an enormous growth during recent years through the introduction of single- and double-base and colloidal systems. A wide choice of high-performance systems is therefore available to the present engine designer and systems engineer.

2. Structure. In addition to large missile structures in general, specific multistage structures have been announced. For example, the Vanguard vehicle is a 4-stage system, three stages being powered, the fourth being the satellite. In September 1956, a three-stage Redstone assembly, using the Redstone missile as first stage, was successfully fired over a distance of 3000 miles. As second stage, a cluster of parallel solid propellants was used, and as third stage, a single solid propellant rocket. The X-17, a USAF re-entry research vehicle, is another example of the use of three-stage systems, the second stage consisting of a cluster of three parallel rockets. NACA-PARD has fired four-stage aerodynamic research. The structural features of the Atlas and Titan missiles have not been announced, but they certainly must represent solutions to the problems involved in creating very light multistaged vehicles.

3. Guidance. The development of guidance systems for long-range ballistic missiles has to satisfy accuracy requirements believed impractical at the end of World War II. Simple flight mechanical considerations show that, for a range of 6000 miles, the penalty

for 1 fps error in cut-off velocity (out of 23,000 fps) is about one mile. Such accuracy, which seems to be of the order required for successful ballistic missiles, is greater than would be required for most other space missions. For launching a satellite into an approximately circular orbit, a cut-off velocity error of about 10 fps (out of about 25,000 fps) is permissible. In fact, the Vanguard tolerance is considerably higher. At lunar distance, a cut-off velocity error of 1 fps (out of 35,000 fps) causes an apogee displacement of the unperturbed ellipse of about 500 n. mi. For simple lunar circumnavigation, such an error would not be critical, unless the minimum distance is selected to be very close to the moon. Actually, the focusing effect of the lunar gravitational field relaxes the accuracy requirements to some ± 10 fps or more, depending upon the mission.

4. *Re-entry.* Here again the ICBM program paves the way for future astronautical experiments. The USAF test missile X-17 is specifically developed to provide experimental data for ICBM nose cones. An ICBM would re-enter the atmosphere at only slightly less speed than a returning space ship. Ground test installations, such as the shock tubes at AVCO, AEDC and the ultra-high speed test facilities at NACA-Ames Laboratories, work toward the solution of the re-entry problem for long-range guided missiles. The problems involved in satellite recovery are simpler, in some respects, than the nose cone re-entry problems of ICBM's.

5. *Instrumentation.* The state of the art of small, low-weight precision instrumentation has been advanced greatly in a decade of high-altitude research with rockets, and is presently brought to a peak in the course of the subminiaturization of Vanguard satellite instrumentation. The Vanguard equipment weight of 10 lb includes power supply and transmitter. The instrumentation weight is therefore less than the 10 lb and includes photocell and circuitary for Lyman alpha radiation measurements, a proton-precession magnetometer, an instrument package for cosmic ray experiments, a miniature magnetic tape recorder for cosmic ray and terrestrial energy balance experiments, four bolometers for energy balance measurements and a resistance strip erosion gage for micrometeorite erosion measurements.

With payloads of the order of 4–6 lb, magnetic field measurements, cosmic ray experiments and micrometeorite impact investigations can be made (and the results transmitted to Earth) from great distances in cislunar space, as far out as 10,000 n. mi. and beyond. A payload of 45 lb is considered adequate today for most near-future scientific space experiments in terrestrial and cislunar space. Such weights compare favorably with the many thousand pounds of long-range missile warheads. By reducing the nose weight to such an extent, flight performance is greatly increased.

6. *Auxiliary Power Supply.* The state of the art in storage battery auxiliary power supply is sufficiently advanced to permit the operation of battery-powered satellites which carry a considerably greater payload than Vanguard (approximately 28 watt-hr per lb of battery weight for activated battery types). However, as the payload becomes more sophisticated, possibly also involving TV transmission, batteries are not suitable because of the complex number of voltages required. Alternate possibilities, such as the fuel cell battery, the solar battery and the nuclear reactor battery, are presently under development. Among these, the fuel cell battery and the nuclear reactor battery can yield high wattage. Less than a decade from now, the space vehicle designer will be able to select among a variety of auxiliary power devices to satisfy special requirements regarding voltages, space, weight, duration and intensity of power drainage.

7. *Ground Test Facilities.* A great number of Armed Forces and private industry test facilities are available for ground testing missiles of almost any practical size. Component test facilities, particularly engine test facilities, are numerous in private industry with provisions for testing motors to about 1 million lb of thrust.

8. *Launching Sites.* A well-equipped research and development launching site has been established in recent years by the USAF in Florida (AFMTC). This site is capable of handling all large missiles presently under development, as well as the Vanguard missile. It can be expected that AFMTC will be the model for additional launching sites in the near future.

9. *Tracking and Communication.* Tracking of space vehicles can be done optically and with lesser accuracy by radio. For the optical tracking of low-altitude satellites, the customary long focal-length astronomical telescopes of high precision can not be used, because of the rapid angular motion of the object. Therefore, special equipment of short focal length has been developed for the purpose of tracking Vanguard and other satellites (Baker-Super-Schmidt). For photographic tracking, it is important to note that very high-speed photographic emulsions and developers for greatly improved sensitivity, compared to a few years ago, are available. Still faster speeds (about 50 times those of fast emulsions) are available for photoelectric tracking by means of the image converter and image-tube techniques. Although this latter method is less well developed at this time (lower accuracy in determining the object's position), it holds great promise which makes further developments not only possible, but quite attractive.

It is hoped that optical tracking accuracies with short focal length instruments of the order of 1 sec of arc can be achieved eventually. This would correspond to 5.12 ft at 200 miles or 6144 ft (almost exactly 1 nautical mile) at lunar distance (240,000 miles). In the latter case, however, astronomical long focal-length telescopes could be employed, capable of increasing the tracking accuracy to 0.1–0.01 n. mi. at lunar distance.

For radio tracking, radar and a very accurate phase-comparison technique, based on the interferometer principle, has been developed. Radio tracking has the advantage of being independent of overcast. Thus, through Vanguard, as well as on account of the developments in long-range guided missile tracking, a state of the art has been reached in tracking and communication (telemetering) which is potentially adequate for operations in the entire earth-moon system.

10. *Supporting Industry and Research.* It should summarily be noted here that a tremendous background is available, not only in the form of big companies with a wide variety of research laboratories and test facilities, but equally important, in the form of a large number of smaller enterprises. Industrial companies specialize in liquid or solid rocket engine development, in the development of guidance systems, air frames, power supply, development, and production of new propellants and of new materials for a great range of temperatures from storage of liquid gases to resistance to extreme temperatures. Most important, however, is the scientific approach to engineering development, which has become customary, and the build-up of large, well-managed teams of scientists and engineers.

In this form, industry, research and corresponding government facilities can solve any problem of space flight which will be encountered during the coming years. By integrating apparently remote industrial fields, such as, for example, the fabrication of large balloons, new and important contributions to space flight become possible. Small high-altitude rockets have been fired from balloons and the firing of satellite rockets and even lunar rockets from balloons has been suggested. Of

great importance is the use of balloons in high-altitude biological research. Balloons as carriers of stratospheric observations may eventually enable accurate optical tracking of space vehicles independent of weather conditions.

Supporting research is conducted in the field of materials, electronic equipment, reliability of equipment, in wind tunnels, solar furnaces, electronic arc tunnels, rarefied gas flow facilities, the development of lightweight, high intensity light sources, special electronic computers, miniaturized television equipment, free radicals, receiver signal/noise ratio improvement, attenuation measurements in flames, electronic packaging, improved measuring techniques, miniaturized instrumentation and a host of other activities. Never before in the history of mankind has research in fields potentially contributing to the progress in astronautics been so vigorous and all-embracing as at this time.

11. Advanced Research. In addition to support research, advanced research is in progress directly aimed at increasing our potential capability to conduct space flight. Outstanding examples are the research in the field of nuclear propulsion for rockets, and contracts let by the Air Force (OSR) in the field of plasma flow and ion propulsion systems, as well as Army research in advanced propellants, guidance and tracking.

12. Space Biology. For several years, biological and medical research in connection with high altitude and space flight has been under way by the Air Force and the Navy. Details of this research and its effect on the development of pressure suits, bail-out equipment, etc., are well-known and will not be repeated here. Highlights of this work, from the viewpoint of astronautics, are the high "g" load research, the experiments in weightlessness, the establishment of temperature, pressure, humidity and oxygen deficiency limitations, the effects of sudden decompression, of vibration and of radiation, animal tests with high altitude rockets and balloons and Project Manhigh, involving experiments with humans at altitudes above 100,000 ft for a 24-hr period.

13. Systems Development Management. The development of large missile systems, in this country or elsewhere, will always require close cooperation and management teamwork among agencies of the Department of Defense, the Armed Forces, or other branches of the Government, industry and science. Projects like the Vanguard missile or the ICBM involve countrywide cooperation of organizations under the management of a military-scientific engineering team, organized loosely after the model of the Manhattan project. However, the goal is always quite specific and of comparatively immediate nature, compared to the long-range aspects of an over-all astronautics programs. A special Scientific Advisory Committee assists the Secretary of Defense and provides technical advice and counsel to all three services.

14. National and International Law. There is precedent for considering the space above the sensible atmosphere as the domain of no one nation. Both the U. S. and the U.S.S.R. have announced their intention to fly scientific satellites. These announcements have been received without protest from nations to be overflown. The outlook for "freedom of space" on a par with "freedom of the seas" is good. Establishment of this condition in international law is a prerequisite to any national space flight program.

THE ARS SPACE FLIGHT TECHNICAL COMMITTEE

Karel J. Bossart
Convair-Astronautics

Frederick C. Durant III
Avco Mfg. Corp.

Andrew G. Haley

Richard W. Porter
General Electric Co.

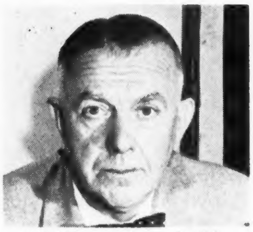
Darrell C. Romick
Goodyear Aircraft Corp.

Milton W. Rosen
Naval Research Lab.

Alexander Satin
Lockheed Aircraft Corp.

S. Fred Singer
University of Maryland

Kurt R. Stehling
Naval Research Lab.



Hubertus Strughold
Randolph AFB

Wernher von Braun
Army Ballistic Missile Agency

Photos not available:

George H. Clement
The Rand Corp.

Maj. George D. Colchagoff
Hq., ARDC

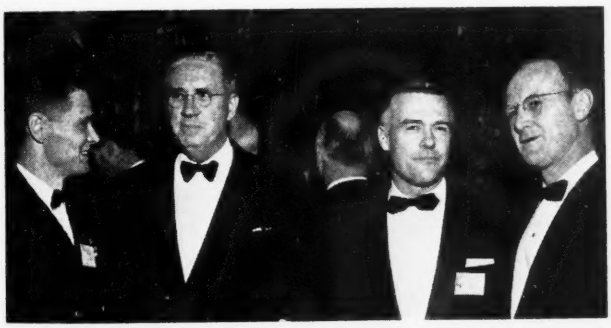
Col. William O. Davis
Wright-Patterson AFB

Head table at New York Section Luncheon. Left to right, James J. Harford, ARS Executive Secretary; President-Elect Sutton; Outgoing President Truax; Robert A. Gross, New York Section President; Krafft Ehricke, Chairman, ARS Space Flight Committee; and Charles Marsel, N. Y. Section Vice-President.

Snapped at the Statler

Left to right, G. Edward Pendray, Mrs. Fred Durant, Irwin Hersey and Mrs. Robert H. Goddard chat at reception prior to Honors Night Dinner.

Wernher von Braun looks glum as Kurt Stehling, just off a plane from Cape Canaveral, discusses difficulties encountered in Vanguard TV-3 launching.



In another group, Robert C. Truax, William M. Holaday, Grayson Merrill and William H. Pickering.

Harry F. Guggenheim and IAS President Mundy Peale smile for the photographer.

Krafft Ehricke, Mrs. & Mr. Otto Winzen and Maj. David G. Simons pause for a moment to pose for a photo.

President-Elect George P. Sutton (left) presents Outgoing President Robert C. Truax with a token of appreciation for his efforts in behalf of ARS during his term of office.

Spotlight on ARS

Record attendance of more than 2000 marks Twelfth Annual Meeting in New York. . . Sutton succeeds Traux as President. . . Stapp wins Vice-Presidency. . . Von Braun, Zucrow, Ramo, Summerfield named to Board of Directors

By Irwin Hersey

EDITOR OF ASTRONAUTICS

WHILE the AMERICAN ROCKET SOCIETY long ago atained maturity in terms of years—it has already celebrated its 27th birthday—it may truly be said to have come of age at the Twelfth Annual Meeting in New York last month.

With interest in rocket and missile technology at an all-time high, neither discouraging news from Cape Canaveral nor a raging blizzard could dampen the high spirits and enthusiasm of the more than 2000 members and guests who attended the meeting, the largest ever held by the Society.

This fact was noted and commented upon by almost everyone in attendance, including guest speakers Joseph Kaplan and William M. Holaday, the Society's national and section officers, rank-and-file ARS members and even the press.

It is indicated not only by the record growth of the Society during the past year—the most successful year in ARS history—and by the record attendance which marked the meeting, the many Technical Sessions, the Honors Night Dinner and other events on the interest-filled five-day program, but also by a growing awareness that ARS has taken its place alongside the many other national engineering and professional societies which have contributed so much to American progress in so many different fields of activity.

As many speakers pointed out, this new maturity must indeed be a source of pride and satisfaction to long-time members of the Society, who have watched it grow from a handful of dedicated people into an organization which gives promise of pass-

Elected to Top American Rocket Society Posts

George P. Sutton
President

The new President of the American Rocket Society is now Chief of Preliminary Design for Rocketdyne, a division of North American Aviation, Inc., Canoga Park, Calif. Holder of B.S. and M.S. degrees from the California Institute of Technology, he has been an instructor at Cal Tech, U.S.C. and U.C.L.A. An employe of Aerojet-General Corp. from 1942 to 1946, he has been with North American since 1946. The first president and one of the co-founders of the ARS Southern California Section, he has been a member of the ARS Board since 1954 and was National Vice-President during 1957. He received the G. Edward Pendray Award in 1951 for his book, "Rocket Propulsion Elements."

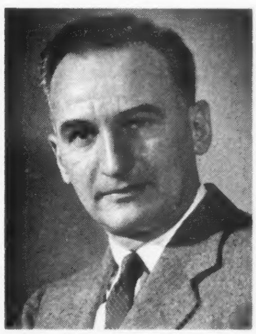
John P. Stapp
Vice-President

Col. John P. Stapp, new ARS Vice-President, is head of the AF Missile Development Center Aero Medical Field Laboratory at Alamogordo, N.M. Holder of four degrees, including a Ph.D. from the University of Texas in 1940 and an M.D. from the University of Minnesota in 1944, Col. Stapp is perhaps best known for his part in the rocket sled human deceleration studies for which he received a Legion of Merit in 1952. A member of the ARS Board and Chairman of its Membership Committee, he is a Fellow in Aviation of the Aero Medical Assn., and in 1954 received the Air Power Award for Science of the AF Assn. In 1955, he was the recipient of the ARS James H. Wyld Memorial Award.

New Board Members

Wernher von Braun

Maurice J. Zucrow



Simon Ramo

Martin Summerfield

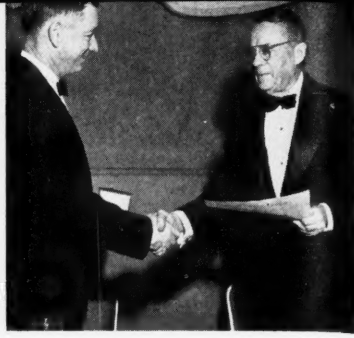
ing the 10,000 mark in the not-too-distant future.

George P. Sutton, chief of preliminary design for Rocketdyne, a division of North American Aviation, Inc., Canoga Park, Calif., will guide the destinies of the Society in the coming year. He succeeds Comdr. Robert C. Truax as ARS President. Election results were announced at the annual Business Meeting.

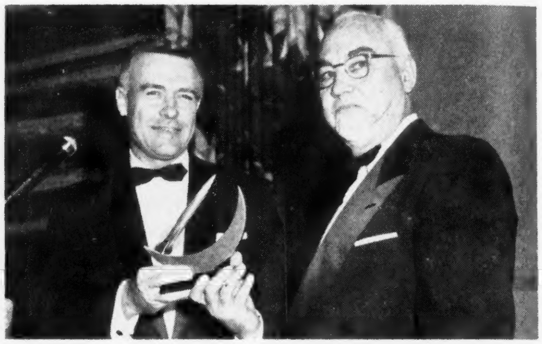
Col. John P. Stapp, head of the Aero Medical Field Laboratory, AF Missile Development Center, Alamogordo, N. M., was elected Vice-President in a close race with Krafft A. Ehricke of Convair-Astronautics and Kurt Stehling of the Naval Research Laboratory.

Elected to full three-year terms on the ARS Board were Wernher von Braun, director, Development Operations Div., Army Ballistic Missile Agency, Huntsville, Ala.; Maurice J. Zucrow, professor of





AWARD WINNERS: Left to right, Thomas F. Dixon of Rocketdyne receives Robert H. Goddard Memorial Award from Mrs. Robert H. Goddard; Mrs. James H. Wyld presents Wyld Award to W. H. Pickering, Jet Propulsion Laboratory; and C. N. Hickman congratulates Capt. Levering H. Smith, Navy BuOrd, on receipt of Hickman Award.

At left, Andrew G. Haley presents ARS Astronautics Award to Krafft Ehricke, Convair-Astronautics, while, at right, Grayson Merrill, Fairchild Guided Missiles Div., accepts G. Edward Pendray Award from ARS Founding Member Pendray.

gas turbines and jet propulsion and director of research, Jet Propulsion Center, Purdue University, W. Lafayette, Ind.; and Simon Ramo, president, Space Technology Laboratories, a division of the Ramo-Wooldridge Corp., Los Angeles, Calif.

Dr. von Braun was re-elected, while Drs. Zucrow and Ramo succeed Milton Rosen of NRL and Andrew G. Haley, whose terms expired at the end of 1957.

Martin Summerfield, professor of jet propulsion, Forrestal Research Center, Princeton University, Princeton, N. J., and Editor of JET PROPULSION, was elected to a two-year term on the Board, filling out Col. Stapp's unexpired term. He will serve until the end of 1959.

Other officers reappointed by the Society are: Robert M. Lawrence, assistant treasurer, Reaction Motors, Inc., Denville, N. J., Treasurer; James J. Harford, Executive Secretary; and A. C. Slade, Secretary. Haley will continue to serve as ARS General Counsel.

The 2000 engineers and scientists from installations and companies throughout the country—and, indeed, from all over the world—who attended the meeting crowded the 18th floor of the Hotel Statler during the week of Dec. 2–6 in an effort to take in as much as possible of the action-packed program, the largest ever presented at an ARS meeting.

They had their choice of 14 Technical Sessions, embracing more than 100 authors and panel members, and covering such diverse subjects as solid and liquid rockets, combustion, propellants, ramjets, instrumentation and guidance, space law and sociology, space flight and human factors. When


Far left, Wernher von Braun reads citation accompanying ARS-Chrysler Corp. $1000 Student Award, as winner John R. Roth, MIT Junior, stands by. At left, President-Elect Sutton congratulates runner-up F. H. Reardon of Princeton University, who received special citation for his paper.

they could find the time, they also attended sessions at the annual meeting of the ASME, held elsewhere in the hotel. They met at three different luncheons and at the annual Honors Night Dinner.

Many made the quick trip up to the New York Coliseum to see the special Rocket and Satellite Exhibit that was part of the 26th Exposition of Chemical Industries. They enjoyed themselves at the New York Section Film Night, jammed the first classified technical session ever held at an annual meeting and took the opportunity to learn a little more about the Society by attending the annual Business Meeting, the first ARS Section Delegates Conference and the first ARS Eastern Regional Student Conference.

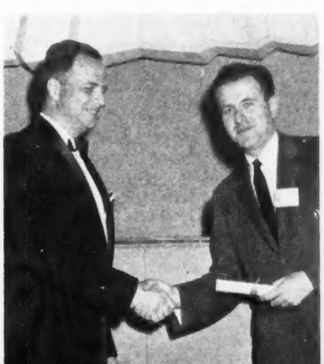
And, of course, sandwiched in between all these events, there was an unending round of questions fired at them by reporters making up what was undoubtedly one of the largest press delegations ever to attend a scientific meeting of this kind, as well as innumerable interviews for radio and TV.

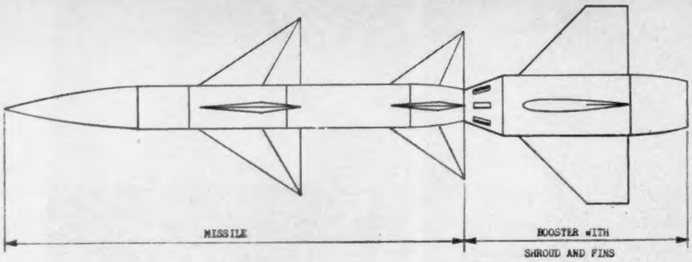
While it would be almost impossible to list all the individual events at the meeting, a few highlights should be noted. Among these were:

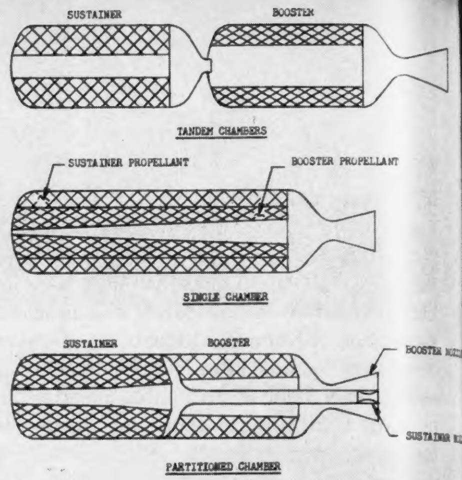
• Announcement at the New York Section Luncheon by Comdr. Truax and Krafft Ehricke, Chairman of the ARS Space Flight Committee, of the proposed national space flight program drawn up by the Committee and now under considera- (CONTINUED ON PAGE 54)

William M. Holaday, Director of Guided Missiles, Defense Dept., speaking at Honors Night Dinner.

NEW FELLOW MEMBERS: Left to right, above, President-Elect Sutton congratulates Maj. David G. Simons, Lt. Col. Langdon F. Ayres and John F. Tormey. Below, Sutton follows through with H. L. Thackwell, Jr., S. Fred Singer, Noah S. Davis and Maj. Gen. John B. Medaris.







BUILT-IN BOOSTER: In thrust staging, dual-thrust solid propellant engine, three configurations for which are shown at right, is simpler, safer and more reliable than typical missile-booster system above.

The race into space

Technical sessions at ARS annual meeting review recent advances in U. S. rocket and missile technology, highlight some significant developments

UNDER heavy attack at home and abroad for its seeming sluggishness, U. S. missilery had its day on the dais last month. The occasion was the 12th Annual Meeting of the American Rocket Society, held at the Hotel Statler in New York Dec. 2–6. The spokesmen were this country's top missile scientists and engineers.

More so than most others, these men were in a position to recognize the real significance of the recent satellite launchings and to put the whole missile picture in its proper perspective. This they did, many times over and mainly on an informal basis.

In their summation of the situation, Russia's recent successes in the missile field were considered a challenge to this country, not a disaster. It is a strong challenge and must be met. More important, they said, it could be and was being met in the many different areas of missile research and development.

In solid propellant rockets, the story was one of steady, significant advances, rather than of spectacular breakthroughs.

• Loren E. Morey, Allegany Ballistics Laboratory, held up the Deacon as an important milestone in the development of solid rockets. Now 10 years old and with no weapons value, the Deacon represented the latest in rocket design for its time, serving as a bridge between ABL's wartime work and peacetime programs. It proved of value in the solution of such classical solid rocket problems as propellant grain fracture because of hard ignition, resonant chamber failure and material control.

But the Deacon really came into its own as a workhorse for boosting aerodynamic test vehicles. NACA has used approximately 650 of them for propelling scale models of the D-558, X-1, X-2, X-3, XB-91, XB-92, F-100, F-101, F-102, F-104, F8U, F10F, F3H, F2Y, F3D, F4D, F5D, F11F, B-58, Sparrow, Falcon, Rascal, Snark, Rigel, Regulus, Boojum, Navaho and Sidewinder.

Used in Special Test Vehicle

In combination with the Honest John, the Deacon was used to make a special test vehicle called the Father John. It has also been used as the power source for a high-speed centrifuge. In modified form, it has served as a precursor for the boosters of Terrier 1 and Nike 1, and for the first stage of the Terrapin.

Today, the Deacon is still playing a useful role. In combination with Nike, it is used in solar flare work. It is also widely used in the Rockoon program. And there is an outstanding order for another

61 Deacons for Operation Pogo, in which the rocket will carry high altitude radar targets.

Solid Rockets

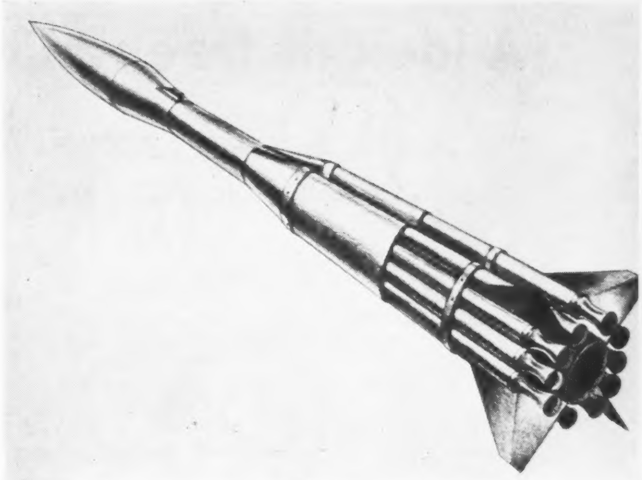
• Solid rockets have come a long way since the Deacon. Just how far was suggested by Aerojet-General's R. S. Newman in his discussion of the dual-thrust solid propellant rocket engine.

It has long been recognized, said Newman, that thrust staging provides the most efficient means of powering a missile to a desired velocity within a specified time. The conventional booster-sustainer system, to which family the Deacon belongs, is one way of doing this, and offers the advantage of being able to jettison booster dead weight once it has served its purpose.

But this system also has its disadvantages. The falling booster constitutes a hazard; separation is often a problem, requiring the use of ejection devices with their additional weight; and, finally, the problem of obtaining the proper ignition sequence.

All these disadvantages, Newman added, can be eliminated by using dual-thrust engines such as those now under development. These fall into three categories: Two chambers in tandem with one propellant in each chamber; one or two propellants in one chamber; or one partitioned chamber with one propellant in each section.

Although the dual-thrust system is handicapped by having to carry the extra weight of a larger chamber, it represents a significant step forward for solids. Among other things, it shows how a single solid rocket engine can be tailor-made to fit a missile system simply, reliably and economically.



FATHER JOHN: A special test configuration in the Honest John system, it consists of a standard M-6 JATO in combination with six to 10 Deacons.

TWO DEACONS powered this huge Sandia Corp. centrifuge to a top speed of 157.5 mph.

Ramjets

There is an important gap in the jet propulsion spectrum that can be filled best—if not solely—by the ramjet. Yet, compared to turbojets and rockets ramjets constitute a virtual unknown today.

Appearances to the contrary, however, interest in ramjets is not dead. And progress in this area is being made steadily, albeit quietly. Some of the most notable advances in this area are taking place in the field of fuels. The approach here again has not been one of spectacular breakthroughs, but rather one of step-by-step optimization.

• W. G. Berl and W. T. Renich, of Johns Hopkins University's Applied Physics Laboratory, pointed out that a number of good ramjet fuels are now available, and selection of the most suitable fuel for a particular operation depends upon factors such as availability, cost, and specific impulse.

In their paper, "Fuels for Ramjets," the authors limited themselves to thermochemical and kinetic criteria. From this viewpoint, they felt it was desirable to concentrate on hydrogen derivatives of boron, carbon or beryllium if high fuel specific impulse values are desirable.

Solely from the thermochemical angle, they concluded that boron-hydrogen compounds seem to be best, followed by hydrogen derivatives of carbon. Thermodynamic considerations narrow the focus to diborane and pentaborane, which also appear to possess very favorable kinetic properties. But, the authors pointed out, experiments on the combustion of diborane and pentaborane have not always produced expected performance.

Thus, they conclude, only in special cases can the use of high energy or (CONTINUED ON PAGE 86)

A look at free radicals

Cryogenics research may indicate the best way to utilize "non-redox" fuel systems of this type, which show great promise as high-energy propellants

By G. C. Szego and E. A. Mickle

GENERAL ELECTRIC CO., CINCINNATI, OHIO

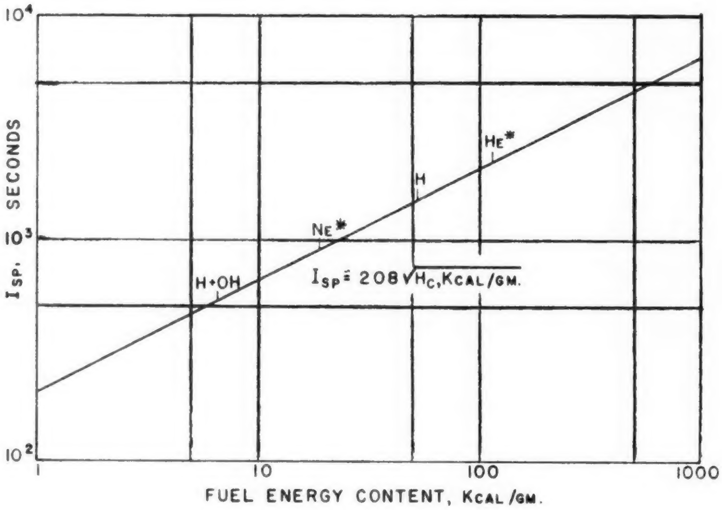
THE PERFORMANCE requirements of future rocket propulsion systems will demand substantial improvement in fuel capabilities. The limitations of purely chemical fuels, i.e., those whose energy-giving capabilities are based on the breaking of one bond and the reformation of another, appear to be about 400 sec specific impulse. In seeking to free his designs from this limitation, the rocket engineer looks to new fuels for the magnitudes of energy content he will require for the successful application of the rocket art to future mission requirements.

A number of sources of energy and means of applying them have been proposed which fall into the category of "non-redox" systems. By "redox" is meant those conventional chemical reactions which are typified by the oxidation of a fuel substance and the reduction of an oxidant, as in the combustion of JP-4 with LOX.

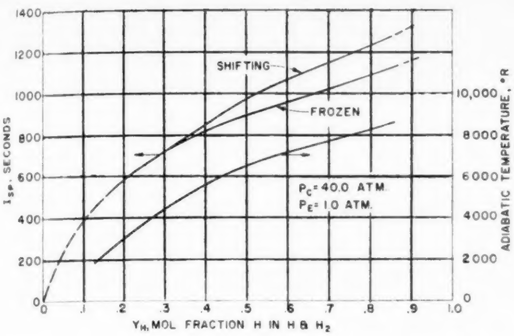
Free radicals form an interesting group of energy sources among the proposed "exotic" fuels. Free radicals may be defined as unstable molecular fragments of a stable chemical species. Another view characterizes a free radical as any combination of atoms which results in unpaired electrons of the outer shell. The chemical concept of the "radical," a group of atoms which acts as a unit in molecular exchange reactions, is traceable to Liebig. The identification in 1900 of the triphenyl methyl free radical by Gomberg, at the University of Michigan, demonstrated for the first time that such "radicals" could exist in the free state, and set off an intensive search for them.

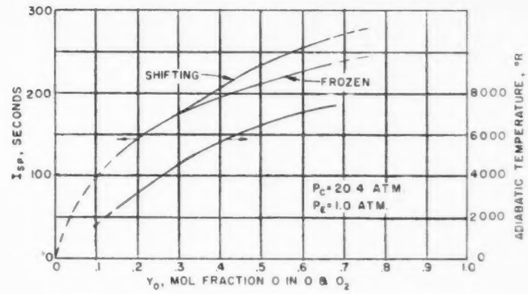
Great impetus was given this work by the famous mirror experiments of Paneth in 1929, which proved for the first time the existence of the aliphatic free radical, methyl. Rapid progress followed, in both the organic and inorganic fields. Many technological advances, now commonplace, depend, knowingly or not, upon free radical mechanisms, as for ex-

Based on a paper presented at the ARS 12th Annual Meeting in New York City Dec. 2-5, 1957.



Specific impulse as a function of fuel energy content, showing the markedly enhanced performance capabilities of a few free radicals.





Performance and temperature parameters versus composition. At left, hydrogen free radical in hydrogen, without oxidizer. At right, oxygen free radical in oxygen.

ample, the use of tetraethyl lead as a motor fuel additive to reduce "knock" in internal combustion reciprocating engines.

Free radicals possess considerable energy above that of the parent species. Some typical examples are shown in the table on this page.

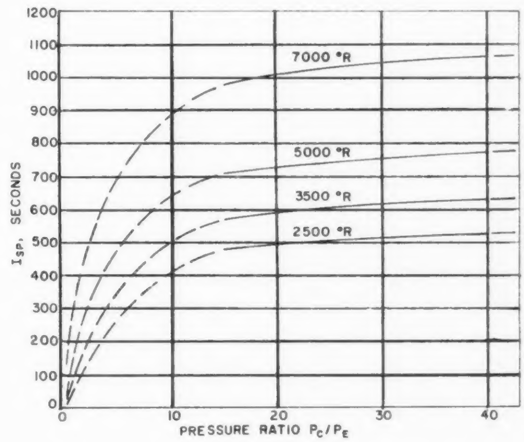
Energy Levels Are Much Greater

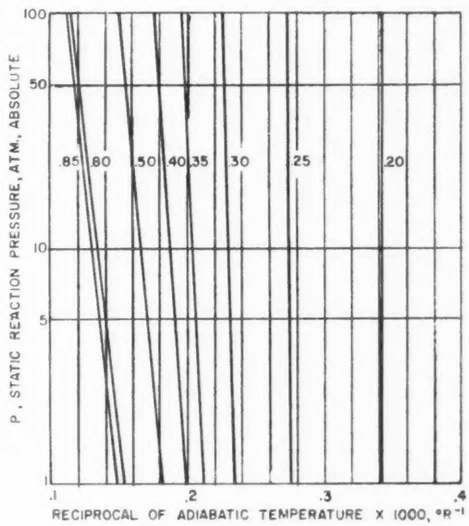
Because their energy levels are so much greater than those of the parent species, free radicals have often been proposed as high-energy propellants. The problems lie in obtaining large enough concentrations of the free radical, stabilizing the radical for usefully long periods of time and effecting rapid but controlled release of this stored energy.

The Department of Defense, because of its interest in high-performance fuels, has undertaken the support, for a three-year period, of an unusual research effort at the National Bureau of Standards

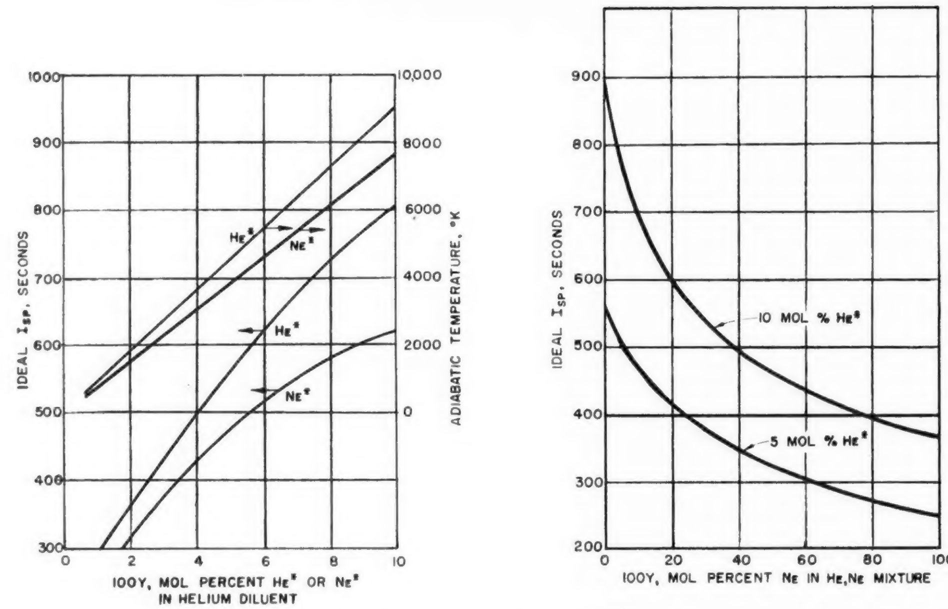
Relative Energy Content of Free Radicals

Parent Species	Radical	Energy of Dissociation, Kcal per gmol of Parent Species	Energy of Dissociation, Kcal per gmol of Parent Species
H_2	H	103.24	51.21
O_2	O	117.17	3.66
N_2	N	224.90	8.03
C_2H_6	CH_3	83.317	2.77
NH_3	N, H	277	16.26
F_2	F	35.6	0.94
CH_4	C, H	363.5	22.66
CH_4	CH_3, H	101	6.30
H_2O	H, OH	118	6.55
NH_3	NH_2, H	102	5.99
Ne	Ne*	380	18.83
He	He*	453	113.17





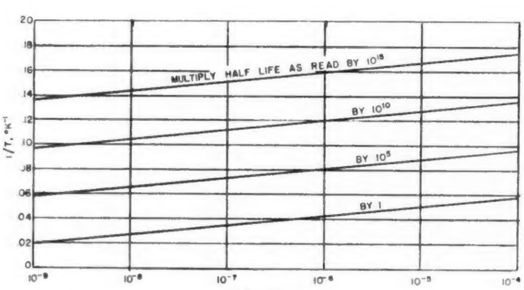
Effect of chamber pressure on specific impulse of H-H_2 systems is shown at top. Effect of pressure on adiabatic reaction temperature at various initial mol fractions of H in H-H_2 systems is illustrated above.



Performance of He° and Ne° diluted with He (left), and of fixed percentages of He° in a Ne, He diluent mixture (right).

in the formation and stabilization of free radicals. At the Bureau, under the direction of Herbert Broida, a team of scientists from the Bureau, universities and industry is now at work on these problems.

While the general propulsive performance of free radicals as rocket fuels has been surveyed, extensive tabular information regarding the thermodynamic properties of free radical systems and their equilibrated mixtures has not been prepared. Such information is important to research workers in free radical systems and to those who seek to evaluate the behavior and performance of presently hypothetical free radical fuels.



Half-life of metastable neon at 300 psia. As temperature drops, half-life increases.

The work discussed here is the result of a contract sponsored by U. S. Army Ordnance for the investigation of the theoretical performance of high-energy propellants at the Rocket Engine Section, Aircraft Gas Turbine Div., General Electric Co., in Cincinnati. Our work involves the computation of performance parameters and thermodynamic properties of the products of free radical and other metastable fuels.

The performance of a rocket fuel is dependent on the energy content of the total propellants. Making the usual assumption that expansion conditions will be such that about one-half of the total energy available is converted into usefully oriented energy, one obtains the well-known relationship: I_{sp}, sec $= 208 \sqrt{H_c}$, Kcal/gm.

Possess Enhanced Performance Capabilities

This relationship is plotted in the graph on page 36. Reference again to the table on page 37 indicates that free radicals would possess markedly enhanced performance capabilities. A few of these are indicated in this graph.

Some more specific performance figures are shown in the first two graphs on page 37. The first graph indicates the performance of H-H_2 mixtures without subsequent oxi- (CONTINUED ON PAGE 64)

Solid propellants and the conquest of space

The best way to achieve very high thrust needed to lift heavy loads associated with space flight, says this solid fuels advocate, is by scaling-up a single solid engine for the first stage, and this we can do today

By Harold W. Ritchey

THIOKOL CHEMICAL CORP., HUNTSVILLE, ALA.

Harold W. Ritchey has since 1949 been Technical Director of Thiokol's rocket activities which are now spread to four divisional locations. In this capacity, he has worked on the design and developed fabrication techniques and manufacturing methods for many advanced solid propellant rockets used in guided missiles. Prior to joining Thiokol, he worked in petroleum research and was with General Electric Co., at Harford, Wash., as an atomic reactor engineer. During World War II, he served as a naval officer, specializing in explosives and rocketry. Dr. Ritchey was the recipient of the 1954 Hickman Award of the American Rocket Society for his work in solid propellants, and is now a member of the ARS national board of directors.

THE TITLE of this article injects us immediately into a field so controversial that it seems necessary to delay the principal argument until the reader is properly oriented with respect to the present status of solid propellant rocket technology.

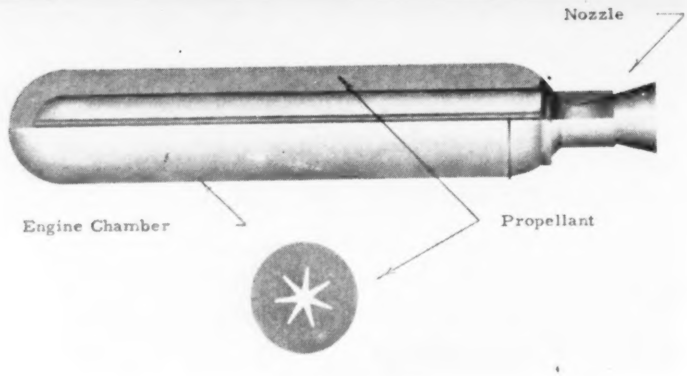
The work of Goddard with liquid fuels constituted the first realistic approach to the problem of obtaining high-performance rockets. This foundation was built on by the Peenemünde group and created a tremendous impact on world opinion, both in the political and technological sense. Most of us who had followed the progress of rocket technology over a period of 20 years prior to the mid-1940's had formed a firm opinion that solid propellant rockets had no future in applications requiring large size, long duration or high ratios of fuel to inert engine components. It seems this opinion is still widely held by a large number of very competent engineers and scientists who have not taken the trouble to acquaint themselves with progress in solid propellant rocket technology.

The very poor competitive position of solid fuel rockets in the mid-'40's was caused not so much by the achievements of the liquid fuel rocket but more by the deplorable state of the art in the solid propellant field itself. Starting with the Chinese in the 12th to 13th Century, extending through the days of Congreve, to the rockets in use during World War II, it was possible to make a number of derogatory statements concerning solid fuel rockets and make these charges stick. Some of the more important of these charges are:

1. *"Solid fuel rockets are hazardous and unpredictable bombs full of explosive, and cannot be counted upon for reliable performance."*

Early rockets were indeed crude pressure vessels with a charge of black powder tamped in place or with sticks of smokeless powder of unpredictable physical and burning characteristics. Until the mid-'40's, the indictment was difficult to refute.

2. *"Good fuel mass ratios and long durations cannot be attained because the walls of the pressure vessels are always exposed to heat, and the entire charge must be packaged in a high-pressure combustion chamber."*



Typical cast-in-place, case-bonded, internal-burning solid rocket.

Heavy insulating coatings, propellant volume losses and thick pressure vessel walls were necessary to insure performance of a solid propellant rocket. This was indeed true in the days when rockets were composed of external burning powder sticks, and, with such design limitations, there seemed to be no way to correct this basic deficiency.

3. *"Solid propellant rockets cannot be adapted to incorporate thrust vector control and thrust termination."*

The real breakthrough in the field of solid propellant rocket technology came shortly after the mid-'40's, when the Jet Propulsion Laboratories at the California Institute of Technology, working under a contract with Army Ordnance, demonstrated the fundamental advantages of the cast-in-place, internal-burning propellant charge supported by bonding it to the wall of the pressure vessel. The application and extension of this simple concept permitted a major breakthrough in the field of rocket technology.

Solids and Liquids Compared

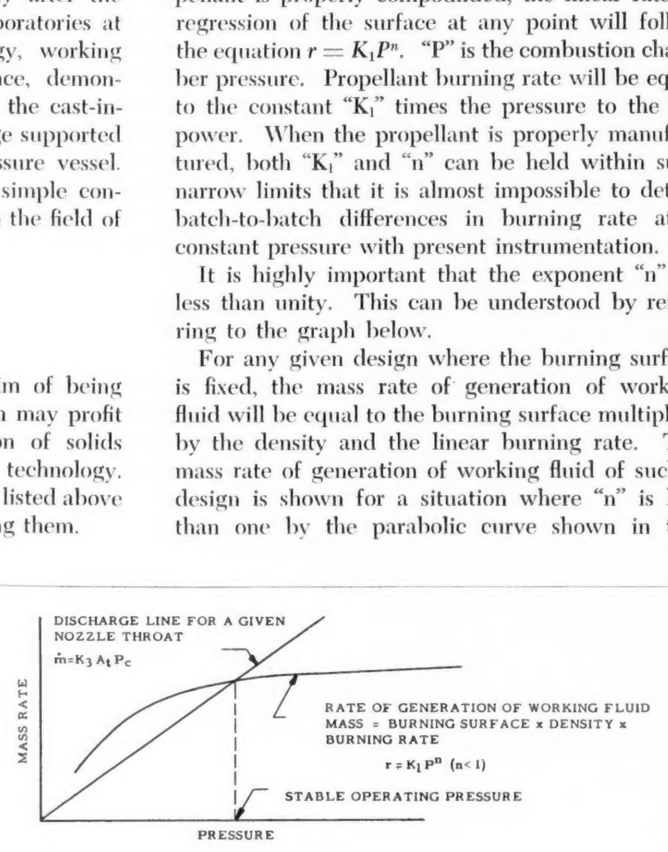
Those who wish to retain their claim of being experts in the field of rocket propulsion may profit by examining the competitive position of solids versus liquids in the light of today's technology. Let's consider each of the major charges listed above and see what can be done about refuting them.

A rebuttal to the first charge can be established only for those who are willing to take the time to develop a fundamental understanding of how a solid propellant rocket charge operates. A typical solid propellant rocket is shown above. Internal perforation is arranged to provide a constant burning surface during the entire operation of the engine so that pressure and thrust are essentially constant. Since burning occurs from the inside outward, the flame does not contact the walls of the pressure vessel until the end of the burning period when the pressure starts to drop. When the propellant is properly compounded, the linear rate of regression of the surface at any point will follow the equation $r = K_1P^n$. "P" is the combustion chamber pressure. Propellant burning rate will be equal to the constant "K_1" times the pressure to the "n" power. When the propellant is properly manufactured, both "K_1" and "n" can be held within such narrow limits that it is almost impossible to detect batch-to-batch differences in burning rate at a constant pressure with present instrumentation.

It is highly important that the exponent "n" be less than unity. This can be understood by referring to the graph below.

For any given design where the burning surface is fixed, the mass rate of generation of working fluid will be equal to the burning surface multiplied by the density and the linear burning rate. The mass rate of generation of working fluid of such a design is shown for a situation where "n" is less than one by the parabolic curve shown in this

Mass rate of "injection" and ejection of propellants as a function of pressure in solid propellant rockets.



graph. On the other hand, gas is discharged sonically through the nozzle throat in accordance with the straight line shown on the graph. This relationship is linear with pressure if the thrust, nozzle throat area and thermodynamic constants of the exhaust gases are fixed. It is obvious that, where these two curves cross, a stable pressure is attained for the system (as long as the charge maintains its mechanical integrity so that the burning surface corresponds to the design value).

As long as the nozzle throat remains the designed size, it is impossible for the rocket to operate at any other pressure. With any given design, of course, this operating pressure can be changed by changing the propellant burning rate, burning surface or nozzle throat area. Choice of propellant composition and geometry permits a wide range of pre-programmed thrust characteristics depending upon the requirements of a particular missile system.

Present Only a Fire Hazard

In regard to the application of the word "explosive" to the solid propellant, it should be pointed out that the large majority of the composite propellant compositions in use today will not sustain a detonation wave even when boosted with extremely high initiating detonators, and therefore present a fire hazard only. Most of these materials, as Ordnance Class 2 "explosives," require fire barriers and quantity separation based on a material that is non-detonating in nature and constitutes only a fire hazard.

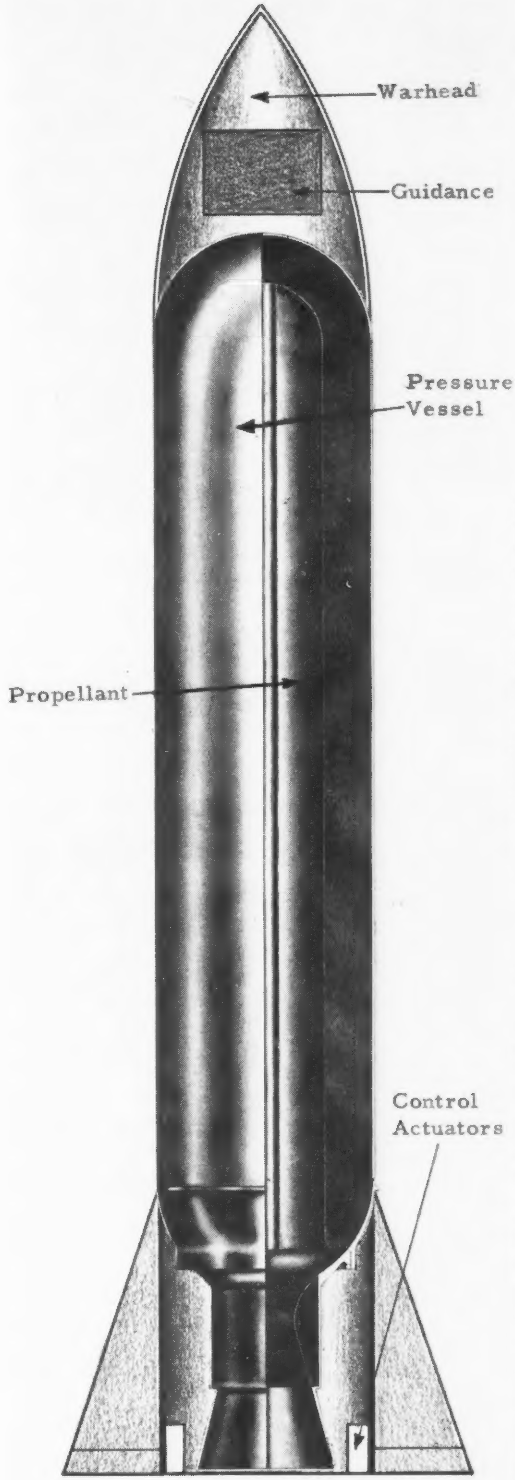
Part of the rebuttal to the second indictment has been established in the preceding paragraph, where it is pointed out that the internal burning grain protects the walls of the pressure vessel against hot gas. It is therefore possible to utilize the cold strength of the metal in pressure vessel design, and insulating coatings are necessary over such a small portion of the internal rocket surface that volume and weight penalties are practically negligible.

(CONTINUED ON PAGE 75)

THEORETICAL ATTAINABLE VELOCITIES

With Assumed Engine Performance Parameters

	Vehicle I	Vehicle II	Vehicle III
Propellant I_{sp} at designed operating pressure and sea level	195	225	260
Propellant weight/total engine weight	0.85	0.92	0.92
Take-off weight/lb payload	3125	625	125
Theoretical velocity (fps)	39,700	42,600	43,500
Number of stages	5	4	3



Fuel tank of this type, utilized in solid rocket, carries aerodynamic loads imposed in flight, permits elimination of large portion of missile structure.

The Douglas-Tulsa high-altitude test chamber. ECM compartment from B-66 is being dynamically tested here. Photo also shows master control for chamber.

Human factors and space cabins

A look at the engineering and technological problems associated with keeping living components operating at peak efficiency in space, and how R & D work in this area is helping in the solution of such problems

By Eugene B. Konecci

HEAD, HUMAN FACTORS GROUP, DOUGLAS AIRCRAFT CO., INC., TULSA, OKLA.

"THERE'LL always be a man" is a phrase that has a significant bearing on human factors efforts in the conquest of space, since the human element is continuously present in the design, construction, servicing and testing of space vehicles. In addition, if man is to travel beyond the earth's protective air-blanket for a period of days, months or years, an assumption must be made that the engineering and technological problems associated with man's well-being in space can be solved. The prime responsibility of human factors in astronautics is thus to insure that the human components in space vehicles are maintained at peak efficiency.

One prerequisite for insuring peak efficiency is to provide astronauts with adequate protection against those environmental hazards inherent in orbital exospheric flight and interplanetary travel. Other factors include keeping space men physically strong, mentally sound and emotionally stable.

In the past, efficiency of a military pilot and crew may have been compromised to gain increased performance of the aircraft. In orbital or interplanetary space flight, however, a compromise at the expense of the human occupant is no longer possible. To fully utilize man's capabilities of perception, judgment based on reasoning and reaction in a man-space-machine relationship, an optimal environment must be furnished the astronaut. A hermetically sealed omni-environmental terrestrial-equivalent space cabin becomes an indispensable requirement to manned space flight. The human factors concerned with such a space cabin, i.e., containing an

Based on a paper presented at the ARS 12th Annual Meeting in New York City Dec. 2–5, 1957.

optimum all-inclusive sea-level environment, are the subject of this article.

It is apparent that all the conditions of space cannot be duplicated on earth. However, most of the factors pertinent to the survival and well-being of the astronaut can be simulated and tested on the ground before the first space flight.

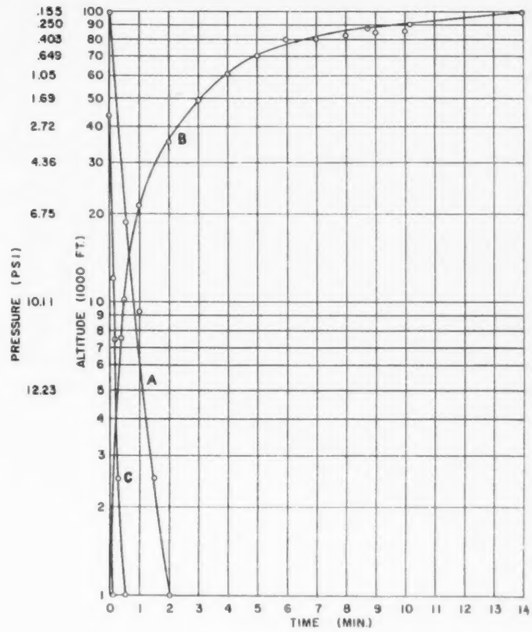
For example, the AF School of Aviation Medicine at Randolph AFB, Tex., is presently studying the medical problems of space flight in its experimental space cabin simulator. These studies include changes in the atmosphere of the cabin caused by the human occupant, the physiologic effects of these changes and methods of controlling them.

Studying High Vacuum Phenomena

Litton Industries, under an AF contract, is studying high vacuum phenomena. The company has constructed a high vacuum altitude chamber 15 ft long and 8 ft diam. The engineering design of the chamber utilized techniques developed in the nuclear energy field for attaining high vacuums in the order of 10^{-6} mm Hg pressure. Litton also designed and fabricated a pressure suit to allow a man to work in the chamber under high vacuum conditions.

(CONTINUED ON PAGE 71)

DOUGLAS—TULSA HIGH-ALTITUDE CHAMBER CAPABILITIES

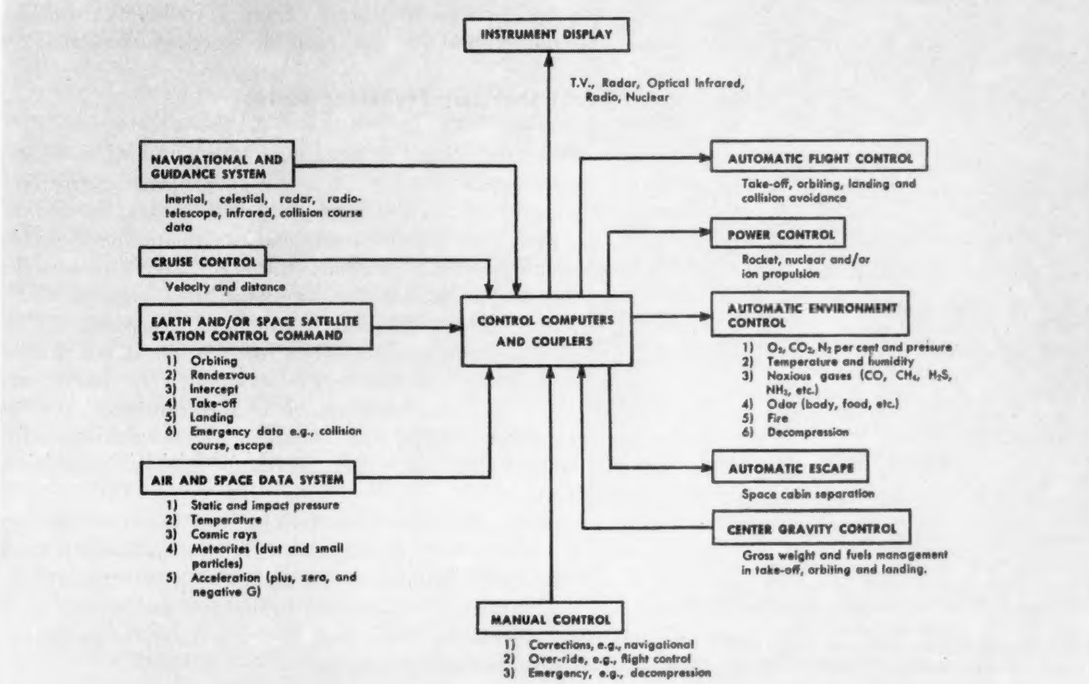


A. MAXIMUM RATE OF DESCENT USING RAM AIR

B. MAXIMUM RATE OF CLIMB USING STEAM JETS

C. EMERGENCY VACUUM DUMP RATE OF DESCENT

GENERAL PARAMETERS OF AUTOMATIC CONTROLS IN SPACE VEHICLES



Aspects of Vanguard propulsion

Previously established techniques as well as new approaches have been used to find the answers to major technical problems, many encountered in the past, but never at one time or of such a degree of complexity

By Kurt R. Stehling

NAVAL RESEARCH LABORATORY, WASHINGTON, D. C.

Kurt R. Stehling is head of the Vanguard propulsion group at the Naval Research Laboratory, charged with supervision of powerplant development for the project. A graduate of the University of Toronto, he worked on high altitude infrared spectrometers and combustion phenomena at the American Optical Co. in Buffalo, N. Y., in 1949–50, and was a rocket research engineer with Bell Aircraft Corp. from 1950 to 1953. In 1953–54, he did research work at the Forrestal Research Center, Princeton University. Prior to joining NRL in 1955, he was acting group leader of Bell's Fluid Mechanics and Heat Transfer Rocket Section in Buffalo.

THE DESIGN of a rocket vehicle can be compared to the design of a racing car, especially from the standpoint of propulsion. For example, if you want to build a racing car which will achieve a certain speed, you can go about it in one of two ways. You either take an existing engine and modify it so that it will produce sufficient power to drive the car at the desired speed or you can start at the very beginning, by designing a brand new engine for the car.

Each of these approaches has certain advantages and disadvantages. Let's say you use the first method. In this case, you take an existing engine and raise the compression ratio, perhaps add a supercharger to increase the fuel-air mixture that gets to the cylinders, redesign and strengthen the camshaft, reduce exhaust back pressure, and use bigger pumps to increase coolant flow and oil velocity.

This gives you a more powerful engine, with more torque, and with working components modified and strengthened so that they can handle this increase in power. Then, if you design a chassis to take the "hot" engine, you can reach the speeds you're aiming for.

Little Doubt that This Technique Works

There's little doubt that this technique works. Indeed, many racing cars in this country are built on this principle. "Souped-up" engines are frequently used with specially modified and "beefed-up" chassis, and cars of this type have set some remarkable speed records.

In the second approach, you start cold and design a new engine from the very beginning. In this way, you can design camshafts, connecting rods, gear trains and ignition systems which are far superior to the common, garden variety found in the standard mass-produced car. Motors of this type are usually very finely tuned and, like thoroughbreds, temperamental and sensitive to minor mechanical defects and fuel contamination, which would not affect a rebuilt engine with the larger tolerances inherent in a mass-produced item.

The Vanguard propulsion system falls midway between these two approaches. It is neither a completely new system nor is it made up of "off-the-shelf" hardware. Its technical roots dig into the fertile soil of previously established propulsion techniques, while several new approaches have been developed which go beyond established practices and principles.

There are some important areas in which the propulsion aspects differ from those used in "conventional" systems and which have required concentrated development and engineering effort.

For example, the combustion efficiency of all three rocket motors—Stages I, II and III—is near the limit of the theoretically possible. This brought problems of heat transfer and stability which in turn raised problems of cooling with the existing materials used in the chambers. Since the first and second stages are liquid propellant rockets, it has been possible, by proper design, to adjust propellant coolant flow rates and jacket pressures so as to absorb the heat flux necessary to maintain the integrity of the combustion chamber liner. However, this has not been done without difficulty.

Results in High Flame Temperature

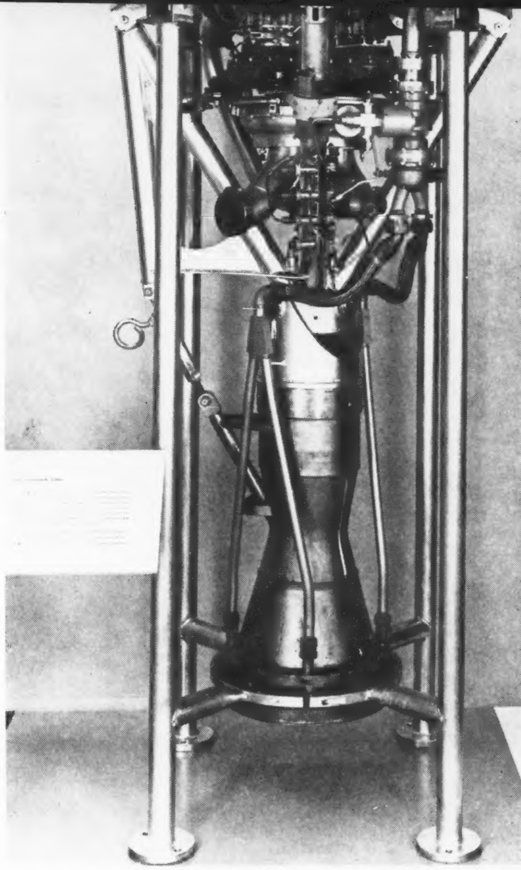
In the first stage, the high chamber pressure results in a high flame temperature. Thus much thought had to be given to the design of coolant passages in which liquid pressure is maintained at a point where the saturation temperature is below the critical value throughout the cooling jacket.

It is, and has been, difficult to sort out the effects of chemical erosion in the chamber caused by oxidization of the metal by free oxidizing components and failure resulting from the coolant being in a critical region, such as "film boiling." In either case, chamber wall failure is possible, but examination of the results in many cases does not determine the cause. It has been difficult also to show the connection between injector flow pattern and chamber wall erosion.

It has yet to be shown that injector flow pattern is primarily responsible for wall erosion. There is no question that the pattern does have some effect, but it is almost impossible to predict the magnitude of this effect. Therefore, it is hard to make adjustments in injector flow pattern in any scientific way, and "rule-of-thumb" methods must be used. Thus every injector designer has his own pet pattern or scheme for a pattern which will not result in chamber wall grooving, scoring or erosion.

Another school of engineers believes chamber cooling capabilities should be beyond the influence of injector erosion, and that cooling should be so thorough and complete that, no matter what the injector tries to do, neither chemical nor physical erosion could occur. That is to say, this school believes the wall temperature should be low enough so that no thermochemical erosion is possible.

It has been shown, in the case of the Vanguard, at least, that adjustment of both these elements, namely the injector and coolant velocity, in the



First-stage Vanguard engine. Built by General Electric Co., it uses a kerosene-LOX propellant combination.

Mock-up of Aerojet-General Stage II engine, attached by "mono-ball" gimbal to oxidizer tank.

SUMMARY OF VANGUARD PROPULSION DATA

STAGE I Engine-General Electric Co.

(a) Thrust: 28,000 lb. (approx.)
(b) Propellants: Kerosene (used as coolant) and liquid oxygen
(c) Burning Time: 2 min (approx.)
(d) Ignition: Pyrotechnic squib
(e) Mounting: Gimbal
(f) Propellant Feed: Turbo-pump, powered by H_2O_2 decomposition
(g) H_2O_2 decomposition "steam" is exhausted through roll-control nozzles
(h) Construction: Steel, double-walled, spiral flow, kerosene-cooled

STAGE II Engine-Aerojet-General Corp.

(a) Thrust: 7500–8000 lb
(b) Propellants: White fuming nitric acid and unsymmetrical dimethyl hydrazine
(c) Burning Time: 2 min (approx.)
(d) Ignition: Propellants are hypergolic
(e) Propellant Feed: From helium-pressurized stainless steel propellant tanks
(f) Mounting: Ball-and-socket gimbal
(g) Control during coasting (burnout) period: Small gas nozzles, using remaining helium, exercise pitch, yaw and roll control
(h) Small solid propellant rockets (Atlantic Research Corp.) fire for one second at end of Stage II flight
(i) Construction: Aluminum tube-bundle, welded and wire-wrapped

STAGE III Engine (Solid Propellant)-Grand Central Rocket Co., Allegany Ballistics Laboratory

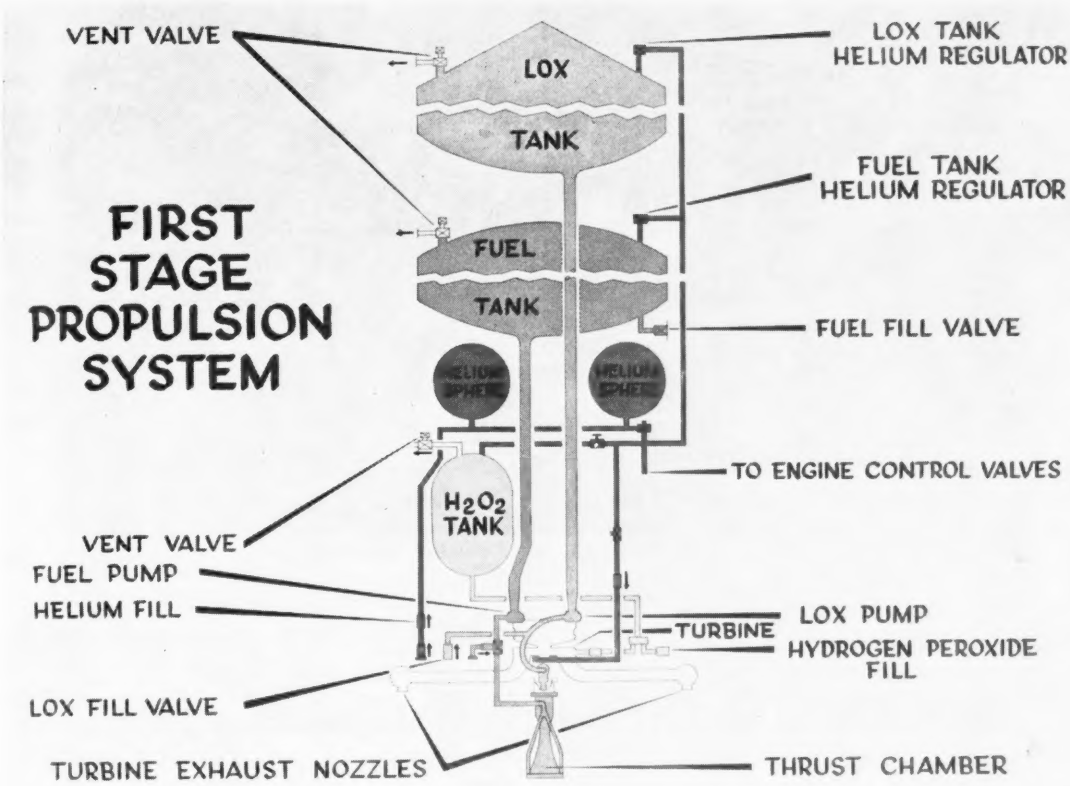
(a) Thrust: 2800 lb
(b) Burning Time: 20–30 sec
(c) Flight Stability: Achieved by spinning unit at 150 rpm (approx.)
(d) Throat Lining: Carbon
(e) Ignition: "Propellant charge" enclosed in restraining tube. 15 sec delay fuse built in to permit spin-up separation of unit. Atmospheric pressure maintained by sealing plug in throat

first-stage engine, has produced an excellent chamber which has survived a rather rigorous acceptance firing schedule.

The second-stage thrust chamber does not operate at a high chamber pressure. Low chamber pressure reduces the heat rejection rate and perhaps increases the gas film heat transfer coefficient. At the same time, however, the liquid film coefficient is reduced and saturation temperature of the acid coolant is lowered to a critical level.

Since the combustion efficiency and temperature of the chamber do not drop significantly with chamber pressure, the second-stage chamber must at the same time be resistant to the heat rejection rate in the combustion process and have a rather low coolant velocity and pressure. Unfortunately, once chamber design is fixed, it is most impractical, within the time scale of this project, at any rate, to change coolant velocity by altering jacket design. Very little adjustment of chamber pressure is possible, since this would be reflected in the pressurized tankage complex, which cannot suffer an increase in internal pressure. If erosion is encountered, the possible remedies are therefore very limited.

It is thus necessary either to reduce the firing time of such a chamber in its testing period and/or to produce an inert coating for the inner walls which will protect these walls from erosion. However, coatings in turn introduce a considerable problem of impermanence and mechanical instability, and tend to increase hot wall thickness. This is contrary to good heat transfer practice, which usually calls for the thinnest possible wall. Furthermore, if the coating is black or dark, it absorbs a large fraction of radiative heat transfer and thus may contribute to wall failure. The writer does not know of any thrust chamber liner coating which has successfully withstood exposure to combustion lasting longer than 80 sec or so. A coating can, however, ameliorate wall failure by "postponing"

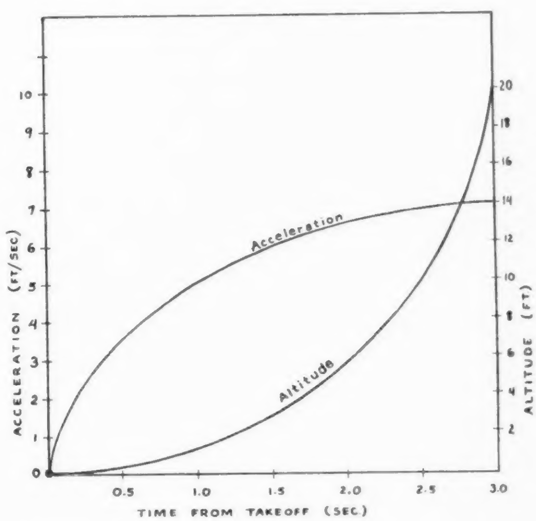


the normal time of failure.

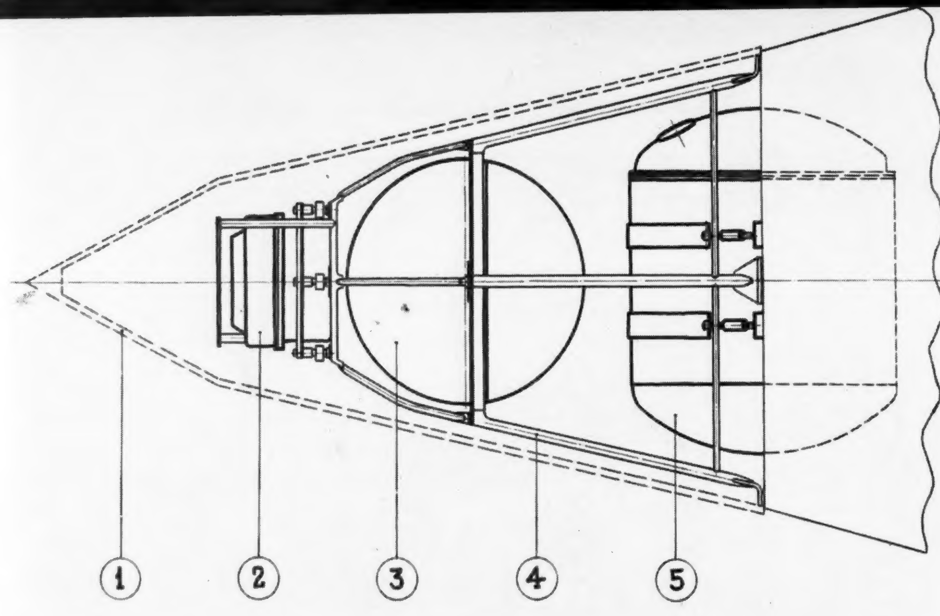
It is even more difficult to make design changes in the solid propellant third-stage rocket, if such changes were necessary. Once the geometry of the rocket and the propellant charge have been determined, very little can be done to adjust either if trouble occurs. The third stage has problems of heat transfer, especially in the almost complete vacuum of the 300 miles or so of launching altitude.

Fortunately, a solid propellant rocket has inherent self-curing properties which the liquid rocket does not have. Chamber heat rejection is controlled by the propellant itself, which acts as an insulator until burnout. The combustion flame is a reducing flame, or at least can be so adjusted, and therefore the use of such throat materials as carbon and molybdenum are possible. These materials have high melting points but are not at all resistant to oxidation. They can, therefore, be efficaciously used in the solid propellant combustion process.

Since the specific impulse in a vacuum is independent of chamber pressure, it has been possible to reduce chamber pres- (CONTINUED ON PAGE 68)



"Getaway" curve for a hypothetical large liquid propellant rocket vehicle. Since getaway is slow, control problems arise if perturbing forces such as high winds are present. Vanguard may encounter such problems.



Schematic of Sputnik II, showing (1) nose cone; (2) instrumentation for measuring solar radiation; (3) capsule containing additional instrumentation and radio transmitters; (4) frame to which instruments and equipment are secured; and (5) sealed chamber housing Laika.

Sputnik II through Russian eyes

Although silent on launching vehicle and means of propulsion, these translations from the Soviet press offer hitherto unreleased data on structure of the satellite and the biological experiments performed

LAUNCHING of the first two Soviet earth satellites is contributing tremendously to knowledge of the upper atmosphere and of the universe.

Sputnik II, with a payload of 1120.29 lb, six times greater than Sputnik I, was placed in orbit by means of a multi-stage rocket. The rocket rose to a height of several hundred kilometers and then, in its last stage, turned to move parallel to the earth at a speed of more than 26,240 fps to become a satellite. Since the speed of the final stage was greater than that required for a circular orbit at that point, the second Sputnik went into an elliptical orbit, with an apogee of 1055 mi, almost double that of Sputnik I.

Because the size of the major semi-axis of the Sputnik II orbit is greater than that of Sputnik I, its period of revolution is also greater—103.7 min at the beginning of its flight. This means Sputnik II makes about 14 full revolutions around the earth in 24 hr, whereas Sputnik I made about 15 revolutions at the beginning of its flight. The shift of each turn of the spiral along the line of longitude due to the earth's sidereal rotation is roughly one-fifteenth larger for Sputnik II than for Sputnik I. The distance between two turns of the earth spiral is accordingly greater by the same value.

The resistance of the earth's atmosphere has had a braking effect on the satellite, and its orbit is thus changing in size and shape. Since the atmosphere is exceedingly rarefied at great altitudes, braking effects acting on the sputnik are negligible, and changes in orbital parameters are therefore very slow.

Sputnik II's life-span depends on the value of this atmospheric braking. It is quite clear that the greater the period of revolution and the lesser the braking, the longer the sputnik's life. Calculations based on data yielded by tracking Sputnik I and its carrier rocket indicate that Sputnik II's life will be about three months, counting the day of its launching. The greater period of revolution of Sputnik II

Sputnik II instrumentation. Capsule with porthole at bottom is container for Laika; upper capsule houses instruments.

Research workers at Pulkov Observatory near Leningrad follow flight of second Soviet satellite.

and the small magnitude of the braking value, which is less than for Sputnik I, indicate that Sputnik II will orbit appreciably longer than Sputnik I.

Present systematization of the results of trajectory measurements will enable us to determine fully the entire process of the evolution of the orbital parameters of both sputniks and obtain important information about density distribution in the top layers of the atmosphere. Later, we shall be able to forecast reliably how long the sputniks will live.

Sputnik II, unlike Sputnik I, is the last stage of a rocket housing all the scientific and measuring equipment. This appreciably simplifies the task of ascertaining the satellite's bearings by means of optical observation, since the experiment with Sputnik I has shown that tracking of the carrier rocket is far simpler than tracking of the satellite itself. The brilliance of the carrier rocket is greater than that of Sputnik I by several stellar magnitudes.

Instrumentation Listed

In the nose of the final stage of the rocket, fixed to a special frame, are instruments for studying solar radiation in the ultraviolet and x-ray regions of the spectrum, a spherical container with radio transmitters and other instruments, and a hermetically sealed chamber to house Laika. Apparatus for cosmic ray investigation is fixed to the rocket body. The devices and containers installed in the rocket were shielded from aerodynamic and heat effects of the rocket's passage through the dense layers of the atmosphere by a special protective nose cone. After the last stage of the rocket was established in its orbit, the protective cone was discarded.

The radio transmitters in the container operated on frequencies of 40.002 and 20.005 mc. The electric batteries, the heat regulation arrangement, and sensitive elements for recording temperature fluctuations and other parameters, were also placed in this container. In structure, the spherical container resembles the first sputnik. (CONTINUED ON PAGE 62)

An engineer records radio signals from Sputnik II at a Soviet Ministry of Communications tracking station.

First satellite results are in

Preliminary scientific reports on Soviet satellites indicate sputniks are bigger than originally estimated

TAKEN BY surprise by the unheralded launching of the first Soviet satellite, scientists at the Smithsonian Astrophysical Observatory and at the U. S. Naval Laboratory lost no time in setting up their vast visual and audio tracking programs. The first observations were made almost before the first broadcasts of the event ebbed off the air. Other observations and tracking reports from around the world followed in rapid succession.

Scientists at the Observatory and NRL went through the reports as they came in, analyzing each one and separating the wheat from the chaff as they went along. The data quickly piled up. It was organized, interpretated and turned into preliminary scientific reports. The first of these reports has now been released.

Termed tentative and even speculative by the authors themselves, the reports are nevertheless interesting and significant. They are also somewhat surprising.

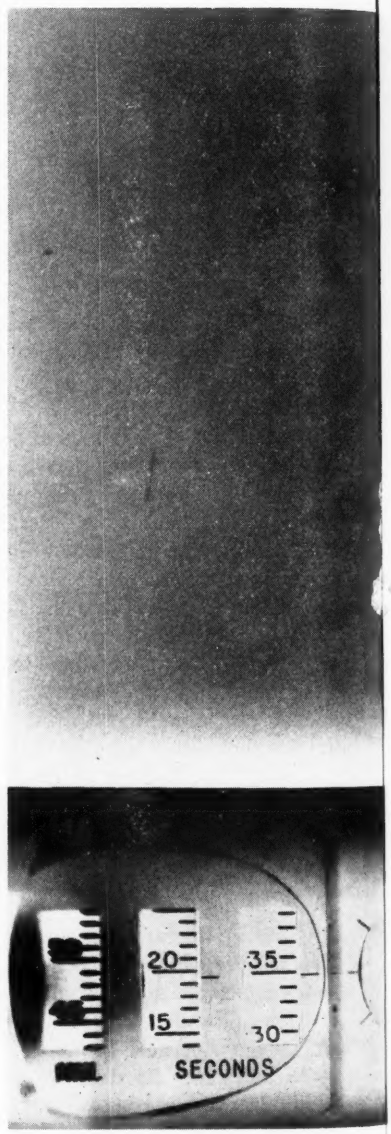
Using what little information was made available (most of it in the form of unconfirmed reports from Russia), Western scientists originally estimated the size and weight of Sputnik I (Alpha 2) as 23 in. in diam and 184 lb (ASTRONAUTICS, December, 1957, p. 31). The third stage rocket that carried it into orbit, Alpha 1, was figured to be about 19 ft long and $2^1/_2$ ft in diam (ASTRONAUTICS, December, 1957, p. 33). Sputnik II (Beta), according to their calculations, was 50 ft long and weighed approximately 1120 lb.

But now, assuming that the diameter of Alpha 2 is 58 cm, scientists at NRL and the Observatory believe the cross-sectional area of Alpha 1 is closer to 26 m^2. They arrived at this figure on the basis of visual and photographic observations of Alpha 1 and Alpha 2. From these observations and estimates of altitude, they derived ratios of relative luminuous intensities.

For exact computations, of course, it is essential to know mass-area ratio, the exact shape of the rocket, and its orientation, including rates of tumbling and spin. As of the date of the report, they carefully point out, none of these qualities is known. (CONTINUED ON PAGE 79)

Air Density of the Upper Atmosphere

Satellite	Altitude	Absolute Density
Alpha 1	220 km	5.7×10^{-14} gm/cm^3
Alpha 2	220 km	4.5×10^{-13} gm/cm^3
Beta	233 km	2.2×10^{-13} gm/cm^3



ON TIME: Caught by a Smithsonian satellite tracking camera, Alpha 1 is shown as it passed over Pasadena, Calif., on October 23, 1957 at 17:48:1935 PST.

Largest weapon shown in Nov. 7 parade in Moscow's Red Square marking 40th anniversary of Russian revolution was this sharp-nosed missile, believed to be T-2 IRBM. Stabilizing fins can be seen at far left.

Soviet missiles on parade

Two-stage, solid propellant, surface-to-air missiles, similar in appearance to Nike family, use large fixed fins as stabilizers, smaller movable fins for control purposes.

These short-range solid propellant rockets, also part of Red missile arsenal, were carried on two different types of mobile launchers. Caterpillar type is shown here.

Truck-mounted Katushin solid propellant barrage rocket batteries pass in front of the reviewing stand during the parade.

missile market

Financial news of the rocket and guided missile industry

BY ROBERT H. KENMORE

THE RECENT launching of the Soviet satellites occasioned one of the sharpest month-to-month rises in the missile index, which jumped 54 points to regain more than half of its decline since the July 1 peak of 621.

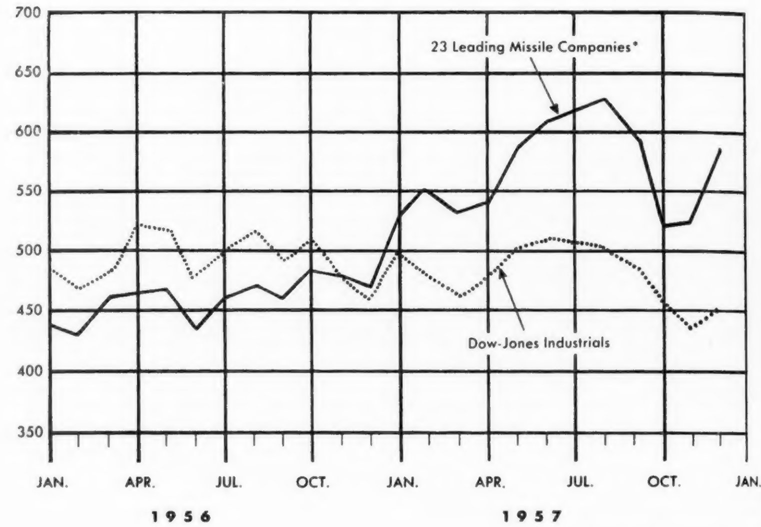
Most prominent individual gains were seen in Douglas (up 16), General Dynamics (up $8^3/_4$), Martin (up 5), North American Aviation (up $7^1/_4$) and Thiokol (up $6^1/_4$). The Dow Jones industrials also managed to show a slight rise, but this was due mostly to the Federal Reserve's cut in the discount rate in late November.

Even as Sputnik I and II started a new chapter in mankind's history, they were also setting off a new pattern of stock market activity. For want of an official Street denomination, it might be said that the market has gotten a bad case of "Washingtonitis."

While it is true that stocks have always heeded the capital's pronouncements, and this is especially true of rocket and guided missile industrials, the market has never in recent history focused so closely, or so nervously, on every echo from Washington. Today it might be said that Washington, *instead* of industry, holds the key to stock market trends.

To be specific: 1. In the past, a contract award would affect the stock movement of the company getting the business; today, if Defense Secretary Neil McElroy sneezes the market goes down five points. 2. Changes in the discount rate by the Federal Reserve Board have also affected markets in the past; the latest change, however, after having been discounted falsely half a dozen times, sent the market up, then down, then up again. Today pundits are undecided whether the move was bullish in that it indicates a reversal of FRB's crippling tight money policy, or whether it is a bearish indication that business must be getting very bad indeed if the rate is cut a full $^1/_2$ per cent in one single action. 3. On Nov. 26, half an hour before the market closed, the President's illness was labeled. After a furious selling spree, Douglas closed in New York at 67, off more than six points, and dropped another point on Pacific Coast markets. Wednesday morning, after everyone (including Mr. Eisenhower) had had a good night's sleep, Douglas opened at $73^1/_4$. In other words, while the market was closed people changed their minds about the valuation of the Douglas Aircraft Co. to the tune of $26,000,000.

THE MARKET AT A GLANCE



*Index compiled June, 1955

	December 1957	November 1957	% Change	December 1956	% Change
Dow-Jones Industrials	450	435	+3.5	467	−3.6
23 Missile Companies	578	524	+9.4	477	+21.2

Predictions Are Difficult

In such a climate, it is obviously impossible to make even reasonably hedged predictions about where the market is going over the short or intermediate terms ahead. Business activity, gross national product, carloadings, employment, etc., can all be charted ahead with some measure of success. Sneezes, coughs, diplomatic gestures and Congressional committees, however, are unpredictable; and, as long as the stock market looks exclusively to them for guidance, it too will remain unpredictable.

Although in saner times it would probably appear extremely paradoxical for such a situation to exist, rocket and guided missile stocks are currently among the most defensive issues on the board, a title usually reserved for utility and food equities. With 1958 general business activity under a cloud of uncertainty and consumers wary of extravagant purchases, the Government (with nobody looking at budgets anymore where our nation's security is concerned) will probably be the most dependable customer around next year.

Selectivity, however, remains the watchword as consolidation of missile projects into fewer but more productive channels will be stressed even more than increased expenditures. Many observers of the current panic feel that the answer is not *more* money, but putting the same amounts into more efficient use. Other factors to keep in mind when making selections are the extreme vulnerability of many smaller concerns even to short-term financial difficulties and the fact that many R&D contracts, even of formidable size, are not always as profitable as they first seemed by the time you get down to a net income figure.

Market Letter Gleanings

"Any strength in the market will probably be concentrated in the groups and issues with the best near-

(CONTINUED ON PAGE 65)

ARS news

Spotlight on ARS

(CONTINUED FROM PAGE 33)

tion in Washington.

• The annual Honors Night Dinner, which drew a crowd of more than 750 members and guests who turned out to pay tribute to fellow rocketeers who have made significant contributions to the state of the art.

• The Student Conference, which was so successful that plans were immediately made to hold a similar conference on the West Coast during the semi-annual ARS meeting in Los Angeles June 9–11. The 200 student delegates who attended heard an outstanding selection of technical papers at a morning meeting, attended a luncheon sponsored by Chrysler Corp. at which Dr. Kaplan was the guest speaker, and were treated to a fascinating discussion of IGY by Dr. Kaplan and Herbert Friedman of NRL at an afternoon session.

• The classified session on liquid rocket propellants and combustion, which was filled to overflowing with ARS members eager to learn of the latest developments in these fields.

• The Section Delegates Conference and luncheon, at which Section officers had a chance to compare notes, air grievances and make suggestions designed to provide closer ties between the national office and individual Sections.

• Announcement of the opening of an Astronautics Information Center for the press in the New York headquarters of the Society. Dean Roberts, ARS Director of Public Relations, will head the Center.

At the Board meeting, action was taken to raise the dues for corporate membership in the Society and to change the method of distribution of ARS publications to Student Members, who will henceforth be offered either ASTRONAUTICS or JET PROPULSION, with the other magazine available at a special subscription price of $5 per year.

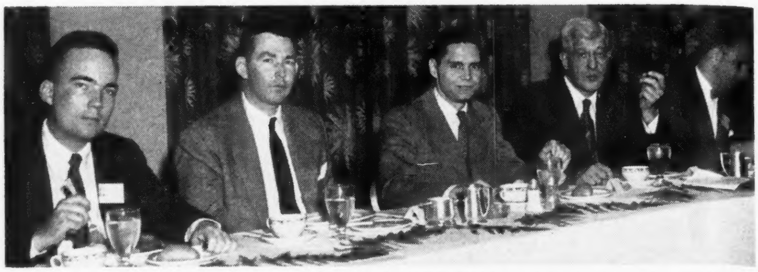
The Board also approved ARS cosponsorship of the Heat Transfer and Fluid Mechanics Institute meeting in San Francisco, June 19–21, and made Fred Durant of Avco Mfg. Co. Chairman of a special committee to raise funds for a Robert H. Goddard Memorial at Worcester Polytechnic Institute, Worcester, Mass., near the site where he successfully fired the first liquid rocket in 1926.

Action was also taken to initiate an ARS advisory committee on amateur rocketry which would work through local ARS Sections to assist youngsters in building and firing rockets under careful supervision. The Board has already authorized submission of letters to the Department of Defense, the National Science Foundation and the President's Committee on Scientists and Engineers endorsing a tentative plan submitted by Lt. Col. C. M. Parkin, ERDL, Fort Belvoir, Va., a member of the National Capital Section.

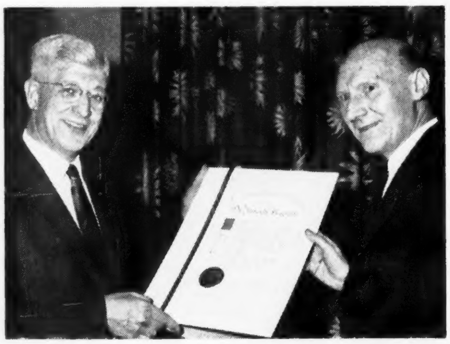
Reports from the Membership Committee at the Board meeting clearly indicated the tremendous growth of the Society in the past year. Membership during 1957 rose by several thousands, and at the end of the year was piling up at the rate of more than 400 new members a month.

In his Treasurer's report, Lawrence noted that the Society had appropriated its available working funds to finance its continuing expansion pro-

At ARS Student Conference Luncheon



Head table at Student Conference Luncheon sponsored by Chrysler Corp. Top, left to right, ARS-Chrysler Student Award winner John R. Roth; Charles W. Williams, Chrysler Missile Operations; Robert C. Traux; Joseph Kaplan; and George Sutton. Above, James J. Harford; T. Paul Torda of the Polytechnic Institute of Brooklyn, faculty advisor to the Host Student Chapter and Chairman of the Review Committee on Student Papers; Ernst Weber, Poly President; and Mario Cardullo, Chairman of the Student Technical Session.



Joseph Kaplan (left), Chairman, USNC-IGY, and Brooklyn Poly President Ernst Weber, with the special commendation presented to Dr. Kaplan by the school.

C. W. Williams of Chrysler makes a few introductory remarks.

gram, marked in 1957 by tremendous membership growth, a second publication, expansion of the national office staff and purchase of new equipment, and expansion of member services.

Comdr. Truax, in his keynote address at the Honors Night Dinner, took over the role of elder statesman (at the ripe old age of 39!) to offer a few words of advice to the Society. If ARS is to keep its position of primacy in rocket development, he warned, "It must mold opinion, not follow it."

After recalling an address delivered at a similar dinner six years earlier in which he had called upon ARS to take the initiative in convincing the nation and the government of the need for a satellite program, he called upon the Society to supply the leadership, long-range planning and foresight necessary to keep us abreast of the Russians in rocket development.

"The ARS is amply endowed with know-how," he noted. "We are now organized to tap this knowledge for any problem. We must now learn to combine the knowledge with insight to produce foresight. If we succeed in doing this, the government and the public will naturally look to us for planning guidance."

"Historically, men have invariably underestimated the consequences of new inventions and discoveries. This applies to inventions in transportation in particular. We laughed at the automobile and ignored the airplane. The rocket has even greater potential. Not only does it promise the ability to go places faster. It also promises the ability to go places we could not reach by other means.

"In this respect, it more closely parallels the ship. It promises discovery as well as convenience, whole new horizons as well as military advantages. Let us, as its prime advocates, not sell it short.

"As I leave my position of responsibility in this organization," he concluded, "I trust and pray that the Society will energetically foster, both technically and politically, full exploitation of the vast inherent potential of rocket vehicles, and that it will be courageous and farsighted in the policies which it advocates."

In his address at the Student Luncheon on the final day of the meeting, Dr. Kaplan, Chairman, USNC-IGY, who had been greeted upon his arrival by news of the Vanguard blowup, cautioned against hysteria over the mishap. He reminded his audience that the failure had come after three successful tests, and that this was not the first time that scientific experiments of this kind had ended in failure, nor the last.

He announced that a plan has already been placed before the International Council of Scientific Unions which calls for continuation of upper atmosphere research utilizing rockets and satellites after the end of IGY, and expressed the hope that such a continuing program would be established.

The internationally known physicist added that it was a great source of satisfaction to him that the U. S. is the only nation which now publishes full results of scientific rocket research, and commented that time and time again at meetings throughout the world scientists of other nations have praised the U. S. for making available such data.

Holaday, Director of Guided Missiles, Department of Defense, speaking at the Honors Night Dinner, briefly reviewed the status of the nation's satellite and guided missile programs, and praised the Society for the role it was playing in these programs.

Missiles Get Priority

He noted that, while we have ICBM hardware capable of launching large satellites, development of missiles must take priority over space flight at this time. This priority is necessary, he said, because right now "satellites are not as militarily useful as a working, dependable ballistic missile system." However, he added, work on space flight is going forward and we will have "an effective and continuing program."

Holaday outlined both short- and long-range programs for the job which confronts us. From the short-range standpoint, he commented, we must increase basic and applied research; be realistic in the selection of development programs; know when to stop such programs and, after completing them, turn immediately to production of military hardware; and utilize to the fullest extent our scientific and engineering personnel. For the long-range job, he added, we must have better teachers and pay more atten-

on the calendar

1958

Jan. 2–3	"Molecular Physics in Chemical Engineering," Case Institute of Technology, Cleveland, Ohio. Sponsored by IEC Div. of American Chemical Society.
Jan. 9, 16, 23, 30	Gas Dynamics Colloquium, Technological Institute, Northwestern U., Evanston, Ill.
Jan. 14–15	Yankee Instrument Fair and Symposium, sponsored by Instrument Society of America, Hotel Bradford, Boston, Mass.
Jan. 29–30	Midwest Welding Conference, Illinois Tech Chemistry Bldg., 3255 S. Dearborn St., Chicago, Ill.
Feb. 4–6	Thirtenth Annual Technical and Management Conference, Reinforced Plastics Div., The Society of the Plastics Industry, Inc., Edgewater Beach Hotel, Chicago.
Feb. 13–15	Spring Meeting of National Society of Professional Engineers, Michigan State U., East Lansing, Mich.
Feb. 26–27	Air Force Assn.'s Third Annual Jet Age Conference and Guided Missile Symposium, Washington, D.C.
March 3–6	International Gas Turbine Power Division Conference and Exhibit, ASME, Washington, D.C.
March 16–21	1958 Nuclear Congress, Chicago, Ill.
March 17–20	**American Rocket Society—ASME Aviation Div. Conference, Statler-Hilton Hotel, Dallas, Tex.**
March 17–21	Fourth Nuclear Engineering and Science Conference, Chicago Inter-National Amphitheatre, Ill.
March 18–19	Conference on Extremely High Temperatures, AF Cambridge Research Center, Bedford, Mass.
March 18–19	Inter-Service and Industry Symposium on Guided Missile Training Equipment, Naval Ordnance Lab., White Oak, Silver Spring, Md.
April 27–May 1	60th Annual Meeting of American Ceramic Society, Penn-Sheraton Hotel, Pittsburgh, Pa.
May 4–7	Fourth National Instrumentation Flight Test Symposium of ISA, Park Sheraton Hotel, NYC.
June 2–4	**National Telemetering Conference under auspices of ARS, IAS, AIEE, ISA, Lord Baltimore Hotel, Baltimore, Md.**
June 9–11	**ARS Semi-Annual Meeting, Hotel Statler, Los Angeles, Calif.**
June 19–21	**Heat Transfer and Fluid Mechanics Institute Meeting, University of California, Berkeley.**
Aug. 24–30	Ninth Annual Congress of International Astronautical Federation, Amsterdam, The Netherlands.
Sept. 15–18	**ARS Meeting, Hotel Statler, Detroit, Mich.**
Sept. 29–30	Basic Science Div., American Ceramic Society, Wright-Patterson AFB, Dayton, Ohio.
Dec. 1–5	**ARS 13th Annual Meeting, New York, N. Y.**

tion to providing better science instruction.

The attitude of those attending the meeting was perhaps best summed up by President-Elect Sutton at the Dinner, who noted that "1957 was a good year, and 1958 should be an even better year for all of us in the Society."

Out-of-Print Copies Of JP Now Available

Under an agreement with the American Rocket Society, Kraus Reprint Corp., 16 E. 46th St., New York 17, N. Y., has made available complete back files of JET PROPULSION, dating back to the first year of publication.

Vols. 1–22 (1930–1952) are offered at $148.50, bound. In addition, Vols. 1–2, 3–7, 8–10 and 11–13 are available at $14 each, unbound; Vol. 14 and 15 at $9 per volume, unbound; Vol. 16, 17, 18, 19, 20 and 21 at $14 per volume, unbound; and Vol. 22 at $12, unbound. Single units or volumes can be supplied bound at $1.50 additionally per unit or volume. Vols. 23–26 are scheduled for reprint early this year.

Kraus is also offering back copies of the *Journal of the British Interplanetary Society*. Vols. 1–14 (1934–1955) are offered at $180, bound; Vols. 1–5 in one volume (sold as a unit only) at $20, unbound; and Vols. 6–14 at $20 per volume unbound.

Chrysler Sponsors ARS Memberships

Chrysler Corp. has set up a program to sponsor 15 memberships in the American Rocket Society each year. The memberships will go to technical personnel showing outstanding ability and performance, and will be paid by Chrysler for the first year, after which it is presumed that memberships will be continued by the individuals selected.

CAI Journal Available to ARS Members at $2 a Year

The American Rocket Society and the Canadian Aeronautical Institute have reached an agreement whereby publications of one society are made available to members of the other group at member rates. Under terms of the agreement, the *Canadian Aeronautical Journal*, published monthly except in July and August by the Institute, is now available to ARS members at $2 a year.

Maryland Section Honors Contest Winners

John Patrick Bevans, first prize winner in Maryland Section Essay Contest for the Baltimore Schools, looks on as Joel M. Jacobson, Aircraft Armaments, Inc., congratulates second prize winner Sally Tilford.

Walter Crotty, vice-president, Maryland Section, says a few words at dinner meeting honoring essay contest winners. Others at head table (left to right): George Lescher, director; Samuel Fradin, president; Mrs. Crotty; J. H. Fischer; and Mr. and Mrs. Joel M. Jacobson.

Seven More Firms Become ARS Corporate Members

Seven more companies active in the rocket and jet propulsion fields have become corporate members of the American Rocket Society. New members, their areas of activity and those named to represent them in the Society are as follows:

Shell Chemical Corp., New York, N. Y., active in the fields of existing and potential rocket fuels, including both mono- and bipropellants and oxidizers, as exemplified by the manufacture of ammonia, high-strength hydrogen peroxide, certain acetylene derivatives and epoxy resins.

Representing the company in the ARS are: B. K. Read, special representative; C. A. Houston, E. R. Kennedy and N. L. Gianakos, senior technologists; and R. H. Hemmerich, section leader.

Vickers, Inc., Aero Hydraulics Div., Detroit, Mich., active in the fields of auxiliary power systems; hydraulic and hot gas servo systems; hydraulic pumps, motors and valves; and alternator drives.

Named to represent the company in ARS activities are: B. W. Badenoch, general manager, Aero Hydraulics Div.; F. L. Moncher, director of engineering; E. I. Brown, chief engineer; A. L. Stone, Western regional sales manager; and J. T. Burns, general sales and service manager.

Hughes Tool Co., Aircraft Div., Culver City, Calif., active in the fields of monopropellant rocket engines for primary thrust applications; liquid

and solid fuel secondary power systems; high-pressure, high-temperature pneumatic valves, regulators and pumps; and synthesis and evaluation of liquid rocket propellants.

Representing the company in the ARS are: C. B. Jones, director of engineering; William E. Wayman, chief powerplant engineer; Louis R. Rapp, head, fuels and propellants section; E. S. Iverson, research and development technical representative, Powerplant Dept.; and Herbert Shieber, head, rocket, motors and gas generators section.

Tele-Dynamics, Inc., Philadelphia, Pa., designer and maufacturer of telemetering, microwave communications, guidance equipment, instrumentation systems and other electronic gear for the missile field.

ARS representatives will be: E. E. Lewis, president; J. B. Elliott, executive vice-president and general manager; L. P. Clark, executive vice-president; H. R. Shaw, vice-president, telemetry and engineering; and E. M. Hatley, assistant to the president.

Koebel Diamond Tool Co., Detroit, Mich., manufacturer of industrial diamond tools and products related to the aircraft and missile industries and engaged in production, research and development of diamond wheels, drills and other products for machining hard fired ceramics.

Named to represent the firm in the ARS are: Charles J. Koebel, president; Robert F. Koebel, vice-president; G. A. Redebaugh, general manager; H. L. Emery, manager-research; and C. L. McCabe, consultant.

The Hicks Corp., Boston, Mass., manufacturer of guided missile components and metal parts, and environmental test equipment.

Representing the company in ARS will be: Thomas Wheeler, president; Arthur Jackson, general manager; John C. Reimers, vice-president in charge of sales; and Andrew Springer and Leo P. Sinclair Jr., sales representatives.

American Aviation Publications, Inc., Washington, D. C., publisher of *Missiles and Rockets* magazine, *Missile Week* newsletter, and 13 other publications and services in the aviation field.

Named as ARS representatives are: Erik Bergaust, executive editor, *Missiles and Rockets;* Robert H. Wood, vice-president and editorial director; Joseph Murphy, executive editor, *American Aviation;* and Norman Baker and Edward S. Hull, assistant editors, *Missiles and Rockets.*

SECTION NOTES

Central California: Over 260 people attended the organization meeting of the Central California Section at Washington School, Santa Barbara, Nov. 16. Aerophysics Development Corp., a subsidiary of Curtiss-Wright, was represented by a delegation of 85, while Raytheon, Santa Barbara Research, General Electric Co. and other local companies were also well represented. In addition, a delegation from the Southern California Section, headed by President J. A. Broadston, also attended the meeting.

The meeting was opened by E. O. Rolle of Aerophysics, while Ernest Steinhoff of the same company introduced the guest speakers, Andrew G. Haley and Welf Heinrich, Prince of Hanover. Mr. Haley, former ARS President and now president of the International Astronautical Federation, and the Prince, author of the first doctoral dissertation on space law, discussed "The Law of the Age of Space." The speakers were presented with photographs taken in Santa Barbara of Sputnik II as a token of thanks for their help in getting the section off the ground.

A 30-min motion picture in color and sound, entitled "The Road to the Stars," produced by Rocketdyne, rounded out the evening's program.

Temporary officers of the group are: Mr. Rolle, president; Dr. Steinhoff, vice-president; D. Bitondo, Aerophysics, secretary and membership chairman; and Peter J. Schenk, General Electric Co., treasurer.

Election of permanent officers will be held after the section receives its charter and all membership applications have been processed.

Holloman: Knox Millsaps, chief scientist, AF Missile Development Center, has been elected president of the Holloman Section for the coming year, succeeding Gerhard R. Eber.

Other new officers of the Section are: Gerhard W. Braun, technical director of ballistic missile test, AFMDC, vice-president; Lt. Col. Harry L. Gephart, secretary; and Bernard D. Gildenberg, treasurer.

Andrew G. Haley, president of the International Astronautical Federation, was the guest of honor and principal speaker at the Section's annual banquet Nov. 19. Another prominent guest and speaker was Welf Heinrich, Prince of Hanover. Both speakers presented interesting discussions of space law at the banquet. Many other notables also attended the event.

Speakers at previous meetings of the Section were James A. Ward, AFMDC mathematician, who discussed "Digital Computers and Their Language," illustrating his talk with an operating flexowriter, a model of the 1103-A computer and a recording of a musical selection composed by a computer; and optical physicist John Strong, who presented a discussion of proposed telescopic observations of Mars to be made from manned balloons.

Maryland: John Patrick Bevans of Baltimore Polytechnic High School won first prize in the first annual Maryland Section ARS Essay Contest for the Baltimore Schools, designed to stimulate interest in the engineering sciences among local high school students. The topic for the contest was "A Look into the Future." Mr. Bevans' prize was $150 in cash.

Second prize, a de luxe portable radio donated by Westinghouse Air Arm Div., went to Sally Tilford of Eastern High School.

The awards were presented by Joel M. Jacobson, vice-president and general manager of Aircraft Armaments, Inc., at a dinner meeting of the Section.

New York: Robert A. Gross, chief research engineer, Fairchild Engine Div., and president of the New York Section, recently appeared on a TV panel show called "Between the Lines" to discuss Russian satellite launchings and U. S. efforts in the rocket, guided missile and space flight fields.

Northern California: A dinner meeting of the Section was held at the Marines' Memorial Club in San Francisco Nov. 14. Andrew G. Haley and Welf Heinrich, Prince of Hanover, were the guest speakers, the evening making up part of their nationwide series of lectures on "The Law of the Age of Space." Members and guests of the Section were joined by a number of interested members of the legal profession. The lectures generated a stimulating question-and-answer period toward the end of the meeting.

At the previous meeting, John F. Tormey, chief of research, Rocketdyne, spoke on "Changing Times in Rocket Propulsion Research." Dr. Tormey's talk was introduced by a motion picture, "Road to the Stars," produced by Rocketdyne and soon to be released for theater and TV showings. In his address, Dr. Tormey described the changes that he has seen occur in the mechanics and attitudes of rocket propulsion research during the past few years.

Alfred J. Eggers has been appointed chairman of the Nominating Committee named to provide a slate of Section officer candidates for the coming year.

North Texas: H. W. Ritchey, technical director of Thiokol Chemical Corp., presented a very interesting talk on "Solid Propellant Rocketry" at a dinner meeting of the section on

Nov. 16 attended by more than 100 members and guests.

The meeting was also marked by the election of officers for 1958. C. F. Crabtree was elected president; J. A. Kerr, vice-president; C. R. Cripliver, secretary; and J. B. Haden, treasurer. All are with Convair.

San Diego: On Nov. 7, the San Diego Section held a joint dinner meeting with the IAS in the IAS Building. About 150 persons heard Comdr. Robert C. Truax, ARS National President, give an autobiographical account of "Some Early Rocket Developments in the Navy." Starting with his first handmade liquid rocket, built at the U. S. Naval Academy in 1937, Comdr. Truax gave a humorous account of the difficulties and frustrations which plagued his progress. His first official naval project, a JATO for sluggish PBY's, brought back memories to many veteran Consolidated engineers. With slides and graphs, Comdr. Truax traced the fate of dozens of attempts through World War II to perfect small liquid rockets. He terminated his history at the time when liquid rockets had gained a definite foothold in Naval thinking, with the establishment of NARTS at Lake Denmark, N. J., and Pt. Mugu, Calif.

At an earlier dinner meeting of the section, attended by about 150 people, J. R. Dempsey spoke on "Development and Future Plans of Convair Astronautics," of which he is general manager. Mr. Dempsey covered the past decade of Convair missile activities, outlined present company policy and speculated on the next several decades of activity. The entire cost of the MX774 project, on which Convair successfully pioneered gimballed engines and integral tanks, would pay for only about 10 days of current Atlas work, he noted. Since the beginning in June, 1954, of the present project, personnel have increased from about 250 to 8000.

Mr. Dempsey discussed the reasons that led to a separate Astronautics Div. and the building of the new plant. He felt the company must create a market for its products. Commercial applications for space craft, such as TV relay stations, appear several decades away.

COMMITTEES

Human Factors: The recent International Astronautical Federation Congress in Barcelona was productive of a number of papers dealing with the human factors side of space flight. Papers were presented by H. J. A. von Beckh of The Martin Co.; Maj. D. G. Simons, holder of the world's altitude record for balloon flights; S. J. Gerathewohl of the School of Aviation Medicine, USAF; and Otto Winzen of Winzen Research, Inc., whose firm manufactured the capsule and balloon used in Maj. Simons' record-breaking flight.

Dr. von Beckh's paper, titled "Multidirectional G Protection in Space Vehicles," dealt with the use of a swiveling device for the occupants of a space vehicle re-entering the earth's atmosphere. This device would permit a space flier to be in a supine position during re-entry and permits endurance of the g forces encountered during such a maneuver.

Maj. Simons' paper, entitled "Observations from the Manhigh II Balloon Capsule at 100,000 ft," discussed the flight through the eyes of the pilot inside the capsule. He also included the requirements of the sealed cabin environment and how they were met, the effects of isolation, both physically and psychologically, how the flight was used to compare the effects of heavy primary cosmic rays on a human with the effects previously observed in animal experiments, and the opportunities presented to learn what manner of workload and what problems arose when an individual attempted to conduct experiments and perform exacting tasks under conditions quite similar to what might be expected in satellite flight.

Dr. Gerathewohl's paper, titled "Producing the Weightless State in Jet Aircraft," outlined the parameters of producing weightlessness for 20–30 sec for use in medical research.

Mr. Winzen's paper, "Operation Manhigh," was a companion paper to that of Maj. Simons and discussed the preparation of the flight and flight operations as seen from outside the capsule. A recent development akin to Maj. Simons' flight was the third manned balloon ascent to stratosphere altitudes conducted by the U. S. Navy during the later part of October. The two observers on this flight primarily collected geophysical data.

The recent Sputnik II satellite, "Muttnik," is a major step forward in space flight and would be of considerable value from a human factors standpoint if the biological data collected were released. An interesting point concerning Sputnik II is that it has been seen to tumble end-over-end rather rapidly as it orbits around the earth. This would preclude exposure of the dog to weightlessness and perhaps indicate the experiment was one of exposure to cosmic and solar x-radiation. Confirmation of satisfactory environment control in the capsule would be of major import.

It is pertinent to note that the next Human Factors session of an ARS meeting will be at the semi-annual meeting in June, 1958, at Los Angeles. Irwin Cooper of Rand Corp. is program subcommittee chairman for that meeting and would welcome any correspondence from any members interested in contributing papers to the meeting. The theme will be biosatellites. Papers on other subjects will be considered if they are of unusual merit.

Space Flight: Frederick C. Durant III, secretary of the Space Flight Committee, reports that more than 600 members of the division have replied to questionnaires sent out to them recently. The questionnaires asked division members to specify interest and qualifications in such areas as guidance and control, instrumentation, human factors, tracking, high-altitude research vehicles, manned satellites and testing. The returns are now being card-indexed for action, and members will be notified as soon as this is completed.

The Training and Education Subcommittee of the division recently sent a questionnaire on educational opportunities in the field of astronautics to 189 colleges and universities. At press time, 76 replies had been received. Of this number, 31 listed courses in a number of different fields of study related to space flight, while 45 indicated that no such courses are now being given or planned in the near future.

CORPORATE MEMBERS

Callery Chemical Co., which has headquarters in Pittsburgh, is building and will operate for the Navy a $38 million HiCal Plant at Muskogee, Okla., as well as its own commercial plant at Lawrence, Kan.

° ° °

A scientific computation and mathematical analysis service for business and industrial organizations is now being offered by **Ramo-Wooldridge Corp.** A new R-W Computation Consulting and Service Bureau will be operated as a part of the company's Digital Computing Center, offering consultation in computer applications and digital computing services, including numerical analysis, programming and equipment rental.

° ° °

Formation of a Commercial Contracts Div. was announced by **Republic Aviation Corp.**, Farmingdale, L. I. Republic, which has produced solely for U. S. military branches for the past 10 years, instituted the new division to provide engineering, development and manufacturing services to industry generally and as a supplier to other

aviation companies and allied industries.

° ° °

Ryan Aeronautical Co. will take the initial step in a major expansion of its electronics section by moving present avionics activities from the company's aircraft plant in San Diego to a 30,000-sq ft Kearny Mesa building leased from Magnatron Corp. of America, Inc. It will provide almost double present space utilized by the Ryan electronics section at the Lindbergh Field Location.

° ° °

Plant expansions totaling $1,000,000 are either under way or nearing completion at **Grand Central Rocket Co.** Among the new facilities are two static test bays each capable of handling solid propellant rockets of 1,000,000 lb thrust; a tooling and rocket assembly building; an administration building wing; a propellant mixing building; and nine additional curing ovens.

° ° °

The largest facility in the eastern U. S. for development and production of fuel controls for turbine, atomic and rocket engines was dedicated at Windsor Locks, Conn., recently. Built by **United Aircraft Corp.** for its Hamilton Standard Div., the building provides 410,000 sq ft of new engineering, manufacturing and testing space.

The division currently is producing air conditioning systems, turbine starters, hydraulic pumps and pneumatic valves, as well as fuel controls, and is developing still newer products for the turbine and missile fields. More than 50 turbine-powered aircraft and missiles are using one or more of the division's new nonpropeller products.

° ° °

Staff, facilities, and assets of Cumberland Optical Co., Silver Spring, Md., have been acquired by **Atlantic Research Corp.**, and will operate as a new division of the Alexandria engineering firm. Production facilities will continue to be located at Silver Spring.

Electromet Columbium Stock

Columbium metal melting stock of the highest purity ever made commercially available has been announced by Electro Metallurgical Co., a Division of Union Carbide Corp. The metal is produced in the form of roundels, and the bar-shaped columbium electrode, used for consumable electrode arc melting into ingots, is prepared by cold compacting the readily compressible roundels. The process is said to result in a melting stock of higher purity than that specified for reactor grade columbium.

An extensive future as a base for a new series of high-temperature alloys is predicted for the metal because of its medium density and high strength at elevated temperatures. Columbium is presently being used for nuclear applications because its low nuclear cross section enables it to withstand radiation damage.

Initial Production Available From First U.S. Titanium Mill

Titanium Metals Corp. of America has announced initial production from its new Toronto, Ohio, plant, the world's first facility devoted exclusively to rolling and forging titanium.

Billets and large rounds, earmarked for civilian and military jet engine applications, are being shipped while engineering work continues in installation of sheet mills scheduled to be in operation early in 1958.

The Toronto plant will provide fully integrated facilities, from sponge through forgings, billets and alloy sheet production. TMCA is jointly owned by National Lead Co. and Allegheny Ludlum Steel Corp.

F-107 Jet Fighter-Bomber Delivered to NACA for Test

Designed to fly more than 1300 mph and climb faster than the speed of sound, the North American F-107 is now being flown by NACA test pilots at Edwards AFB. Power is supplied by the P&W J-75 engine, rated at 15,000-lb thrust without afterburner, and capable of developing up to 22,000-lb thrust for short periods when the afterburner is cut in.

The F-107 has movable tail surfaces instead of hinged rudder and elevators. Automatic slots in the wing leading edge aid in stability and low landing speed.

AIP to Publish New Journal on Fluid Physics

Starting this month, the American Institute of Physics will publish a new journal, The Physics of Fluids. It will be devoted to original contributions covering kinetic theory, statistical mechanics, and structure and general physics of gases, liquids and other fluids, as well as those basic aspects of fluid physics bordering on geophysics, astrophysics, biophysics and other fields of science.

The bimonthly publication will be edited by F. N. Frenkiel, Applied Physics Laboratory, Johns Hopkins University.

Rockets Fired from Helicopter Undergoing Evaluation Tests

A weapons system developed for the Sikorsky H-34 Choctaw helicopter and designed to suppress enemy ground fire is undergoing evaluation tests at Fort Benning, Ga. Included in the armament are forty 2.75 rockets, comparable in power to a 75 mm cannon; two 5-in. anti-tank or anti-submarine rockets; three 50-cal and six 30-cal machine guns and two 20 mm cannons. The rockets, cannon and 30-cal machine guns fire forward from fixed positions on the side of the helicopter; the other weapons are aimed from flexible mounts inside the cabin.

$3 Billion Allocated For Scientific R&D

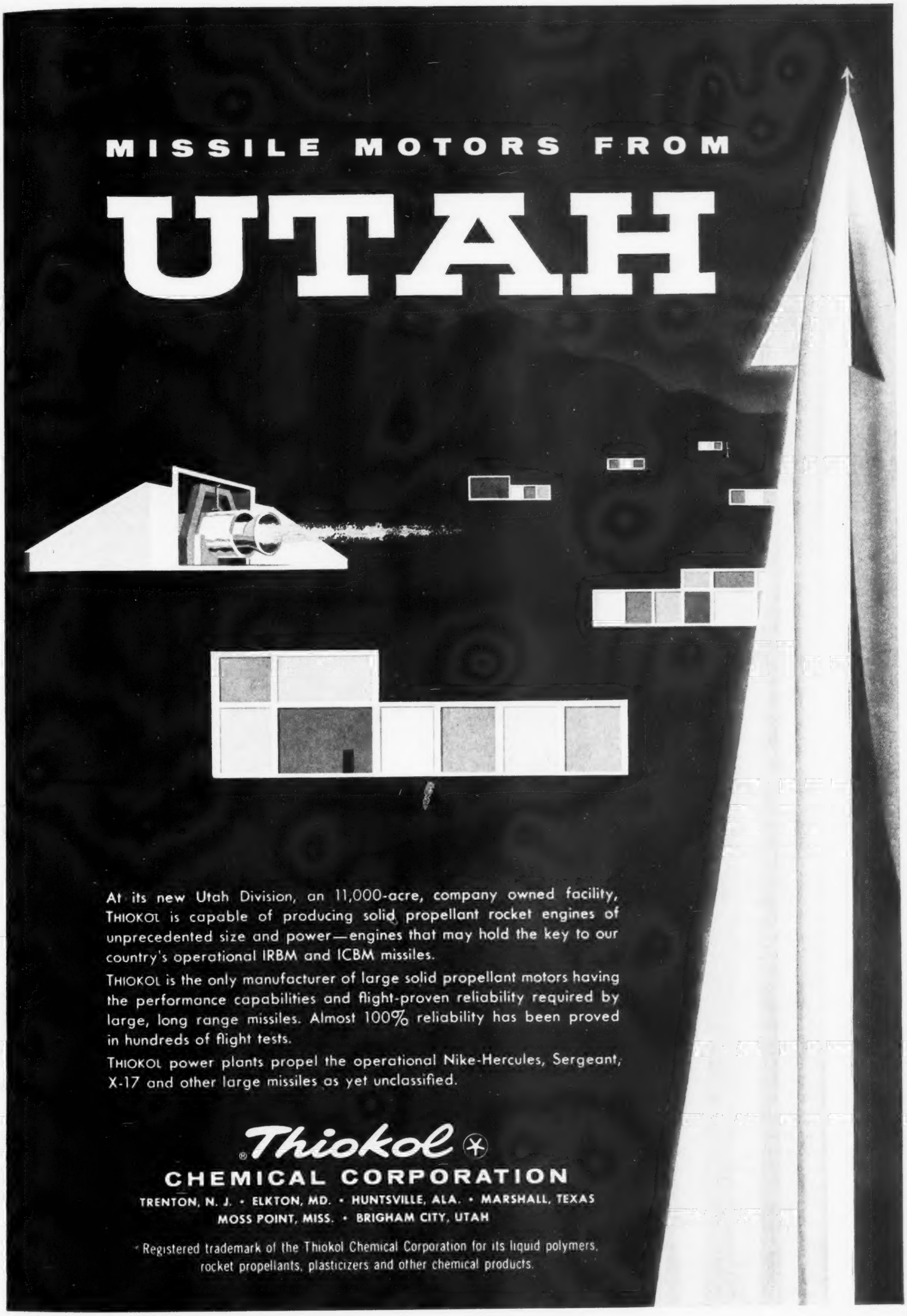
The National Science Foundation has issued a 60-page report providing statistical information for the 1956-58 fiscal years on the obligations and expenditures of Federal agencies engaged in research and development. The report shows that 23 agencies in 1957 obligated over $3 billion for scientific research and development.

Copies of the report are available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at a cost of 40 cents.

NSF Calls For More Basic Research in Sciences

Advocating increased support for basic research in the sciences from private as well as public sources, "Basic Research—A National Resource," a report released by the National Science Foundation, commends for public consideration several far-reaching measures affecting the future of science.

In addition to a statistical and descriptive analysis of the basic U. S. research effort, the report suggests consideration of a number of possible ways to encourage such research. These include increased support to universities for research which conforms to educational and scholarly programs and reduction of support for programs for which the university is not fitted; redefinition of rules under which tax exemption privileges are accorded nonprofit research institutes; changes in federal income tax laws to stimulate private donations for basic research; and a program of federal grants-in-aid to states so as to increase state financial participation in support of basic research.


MISSILE MOTORS FROM
UTAH
At its new Utah Division, an 11,000-acre, company owned facility, THIOKOL is capable of producing solid propellant rocket engines of unprecedented size and power—engines that may hold the key to our country's operational IRBM and ICBM missiles.
THIOKOL is the only manufacturer of large solid propellant motors having the performance capabilities and flight-proven reliability required by large, long range missiles. Almost 100% reliability has been proved in hundreds of flight tests.
THIOKOL power plants propel the operational Nike-Hercules, Sergeant, X-17 and other large missiles as yet unclassified.
®Thiokol
CHEMICAL CORPORATION
TRENTON, N. J. • ELKTON, MD. • HUNTSVILLE, ALA. • MARSHALL, TEXAS
MOSS POINT, MISS. • BRIGHAM CITY, UTAH
® Registered trademark of the Thiokol Chemical Corporation for its liquid polymers, rocket propellants, plasticizers and other chemical products.

Sputnik II

(CONTINUED FROM PAGE 49)

The signals emitted by the radio transmitter working on 20.005 mc were of a telegraphic order averaging around 0.3 sec in length, with a pause of the same length in between. Due to changes in temperature, pressure and other parameters inside the container, the length of the signal and the pause also changed within definite limits.

The transmitter working on 40.002 mc functioned under a continual emission regime. The conformity of the two transmitters to the indicated frequencies insured investigation of the propagation of radio waves emitted from the satellite and measurement of its orbital parameters. Moreover, reception of signals in all ionospheric conditions was guaranteed. Choice of wave lengths, as well as the ample power of the transmitters, enabled the broadest community of amateur radio operators to track the sputnik, along with stations specially assigned to this task.

Equipment in Dog's Cylinder

The hermetically sealed chamber in which Laika was housed was cylindrical in shape. To provide conditions for maintaining normal life, it had a stock of food and an air-conditioning arrangement, consisting of a regeneration installation and a heat regulation system. Along with this, the chamber also contained equipment for recording the pulse beat, breathing and blood pressure of the animal, instruments for taking electrocardiograms and sensitive elements for measuring a number of parameters characterizing conditions inside the chamber, such as temperature and pressure.

Both the chamber for the test animal and the spherical container were made of aluminum alloys. They had a polished surface, specially treated to impart the required coefficients of emission and absorption of solar radiation. The heat-regulating arrangement inside the container and the animal's chamber maintained a set temperature, deflecting the heat into the hull by compulsory gas circulation.

Apart from the indicated equipment, the body of the last stage of the rocket was fitted with telemetering equipment, instruments for temperature measurement, and electric batteries to power the various instruments. Temperature on the outer surface and inside the chamber, and also of the individual devices and elements, was ascertained by means of temperature regulators affixed to them. The telemetering equipment relayed measurements taken to ground stations. Broadcasting of this data was done periodically according to a programmed arrangement.

The research program involved taking measurements over a period of seven days. This program was carried out. The satellite's radio transmitters as well as telemetering equipment have stopped working. Further tracking of Sputnik II to study the characteristic features of the top layers of the atmosphere and forecast its flight is being carried out optically and by radar.

To study medical and biological questions, the special hermetically sealed chamber which contained the dog also had measuring devices to record the animal's physiological functions and equipment for air regeneration, feeding and removal of the animal's excretions. Equipment designs took into consideration requirements for the most stringent economy in size and weight, coupled with minimum power consumption.

Functioning over a long period of time, the apparatus assured telemetered recording of the dog's pulse beat, breathing, arterial blood pressure and cardiac biopotentials, as well as a record of temperature and pressure inside the chamber.

To regenerate the air inside the chamber and maintain its required composition, highly active chemical compounds were employed, giving off the necessary amount of oxygen for inhalation, and absorbing carbon dioxide and surplus water vapor. Chemical reactions were automatically controlled. Due to the absence of air convection under conditions of zero-g, an arrangement for automatic ventilation was installed in the animal's chamber. A set air temperature in the chamber was maintained by a heat regulating arrangement. To give the animal food and water during flight, the container had special automatic feeding devices.

Dog Had Preliminary Training

The dog sent up in the satellite went through a period of preliminary training. It was gradually accustomed to spending protracted periods of time in special clothing in small, hermetically sealed chambers, with equipment attached to its body in different places to record its physiological functions. The dog was also trained to withstand strain, and resistance to the effects of vibration and other factors were ascertained under laboratory conditions. After long training, the animal was able to remain calm inside the chamber over a period of several weeks, thus enabling the necessary scientific investigations to be carried out.

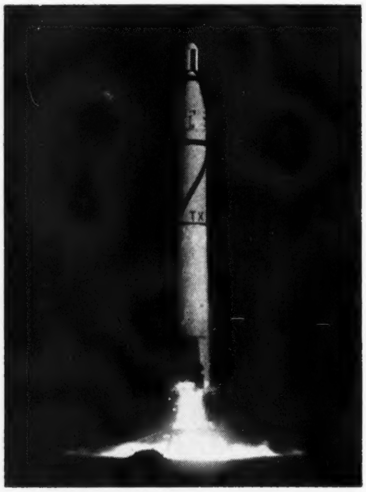
The study of biological phenomena involved in space travel by living organisms was made possible through extensive advance experimentation with animals under conditions of short-term flights aboard rockets. These experiments have been carried out in the U.S.S.R. over a number of years.

The animal's trip aboard Sputnik II makes it possible to study protracted effects of zero-g, or weightlessness. Until now, zero-g effects could be studied aboard aircraft for only a few seconds, or in vertical upward rocket flight for a matter of a few minutes. A satellite makes it possible to study the condition of a living organism in a zero-g state lasting several days.

The experimental data derived from fulfillment of the program of medical and biological research is currently being subjected to most detailed and thorough study. We can already say that the test animal stood up well to the protracted effects of acceleration when the sputnik was being placed in orbit and to the subsequent state of zero-g, which continued for several days. The information received shows that the animal's condition was satisfactory throughout the entire experiment.

Without a doubt, these investigations will largely contribute to coming successful interplanetary voyages and will pave the way for evolving the means to guarantee safety to human beings in space travel.

Proboscis Probe



Special three-stage test configuration of Army's Jupiter IRBM taking off from Cape Canaveral in nose cone re-entry test. Nose cone model is reported to have held up successfully under areodynamic heating encountered upon re-entry.

Free Radicals

(CONTINUED FROM PAGE 38)

dation. In other words, this is a single component system, and the energy derives from the exothermic recombination of hydrogen atoms. This graph is based upon introduction of the fuel at the normal boiling point of H_2, 20.4 K, and a reversible adiabatic nozzle expansion from 40 to 1 atmosphere. This particular system has the lowest molecular weight, and hence possesses very attractive specific impulse characteristics. The second graph shows the properties of the O-O_2 system, expanding from 20.4 to 1 atmosphere, entering at the normal boiling point of oxygen, 90.1 K.

A comparison shows that the performance of the H-H_2 system is roughly four times that of the O-O_2 system, a figure one would expect from the approximately 16-fold ratio of the molecular weights and approximately equivalent bond strengths.

The effect of chamber pressure on the specific impulse of H-H_2 systems when expanded to one atmosphere is shown in the third graph on page 37. The relatively flat portions of the curves at the higher pressures result from the progressively diminishing relative influence of pressure ratio in the specific impulse, compared to the temperature effect. A similar effect would be expected for any free radical system under gas phase operating conditions.

Another means of indicating the pressure effect is indicated in the fourth graph on page 37, wherein is shown the effect of pressure on the adiabatic reaction temperature for various parametric values of initial mol fraction of H in H-H_2 mixtures. The repressive effect of dissociation by elevated pressures is shown to be controlling by the very high slopes of the lines.

Another category of fuel possibilities lies in the metastable excited state of monatomic species. This is another example of a non-redox source of energy. If a noble gas, such as helium or neon, is sufficiently energized, there exists the likelihood that an electron of the outer orbit will jump to a level very significantly higher in energy than that of the ground state. The return of the electron to the ground state would cause the release of the same amount of energy. The quantum mechanical selection rules make a direct return to the ground state relatively improbable. Thus, with the electron in a high-energy orbital, the atom is in a highly energetic and metastable state.

Again referring to the table on page 37, we observe that very attractive levels of performance appear possible for such propellants. The first graph on page 38 indicates levels of theoretical performance at fairly low concentrations of the excited species. The second graph shows the effect of inert diluent composition for fixed concentrations of metastable helium.

The very attractive performance potentials of free radical and metastable atomic systems arouse considerable interest in four problem areas:

1. By what means may these energetic species be generated?
2. To what levels may the generated radicals and excited atoms be concentrated?
3. How and for how long may these maximum concentrations be preserved without the exothermic process taking place?
4. How may the recombination or return to the ground state be initiated and controlled so that the energy given off may be safely and usefully applied in a desirable space of time?

The answer to the first question appears to be fairly well worked out. It is the second and third questions which are presently under study at NBS and elsewhere. The successful resolution of these two questions will probably provide clues to attacking the last problem.

In general, the attack on these questions at present lies in the area of cryogenics. The reasoning behind this is twofold. First, it is thought that solidifying the free radicals as formed will provide immobility, so that their collision and recombination will be prevented. Secondly, the chemical kinetics at very low temperatures may make stabilization possible by reducing at once the effective rate of collision and the energy possessed at collision.

As an example, by making certain simplifying assumptions regarding collision cross sections and statistical behavior, the theoretical half-life of metastable neon has been approximated. The least-squares fit of the data gives:

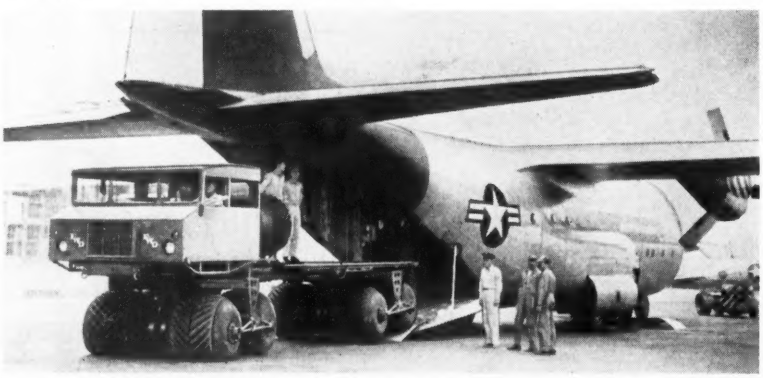
$$\text{Log}_{10}\, t_{HL},\ \text{sec} = \frac{128.82}{T,\ ^\circ K} = 11.4926$$

The third graph on page 38 indicates this half-life as a function of temperature. At low temperatures, the half-life ranges from about 25 sec at 10 K to many years at about 5 K. These figures are intended to give order-of-magnitude, and may be off by several tens. However, it is clear that stability of metastable neon has such a high-temperature coefficient that it may be storable indefinitely at ultra-low temperatures. Catalytic promotion of the exothermic reaction would be unnecessary, as slight warming of the fuel on entering the thrust chamber would initiate the reaction.

It was the purpose of this article to outline the work being carried out in the general field of metastable energetic substances. Additional systems are in process of computation and more complete results will be available shortly.

The general field of free radical and metastable atomic propellants presents certain attractive thermodynamic and performance aspects. The success of the program on the concentration and stabilization of these substances will control the future applications of non-nuclear high-energy propellants.

Support Vehicle for Matador



One of the "pillow-tire" FWD Teracruzers, multi-purpose ground support vehicles in the new TM-61B Matador guided missile weapons system, is driven from the Lockheed C-130 Hercules transport at Orlando AFB. The eight-wheel-drive vehicle moves missiles and their support and launching equipment to launching areas inaccessible to standard trucks.

DATA SHEET

PHILLIPS

REMOVE AND FILE FOR REFERENCE

SERIES 33 SUB-MINIATURE RELAYS

"SNAP-ACTION" DESIGN FOR EXTREME RELIABILITY

Novel snap-over action of this switch eliminates the "floating-contact". High contact pressures, extremely rapid flight time, quick arc quenching, high impact and contact wipe are features accounting for its great reliability and unusually high contact ratings. Impact and wipe of the switch action, especially when combined with special contact materials, results in excellent low-level or "dry circuit" operation. Rapid flight time and arc quenching makes this type switch particularly good with the use of inductive loads. Heat-treated Beryllium copper switch springs are employed for longer fatigue-life running into several million operations. Large contact blades offer good heat dissipation for long contact life.

SERIES 33 ASSEMBLY FEATURES:

DC-33 relays are constructed to withstand destructive shock tests of more than 100 G's without mechanical damage, and high operative shock and vibration tests without contact chatter or opening.

Standard coil and contact rating, listed on reverse side, are conservative. Additional ratings are available for special requirements.

Temperature range for the standard unit is from −65° C to 125° C. Wider temperature ranges available on request.

Terminal header and enclosure are designed to meet military requirements of leakage to specifications MIL-R-5757 and MIL-R-25018. Insulation within enclosure is of high-temperature inorganic type, preventing contamination of contacts.

Addition of a high temperature full-wave bridge rectifier is possible by extending length of the relay body to 1.5 inches.

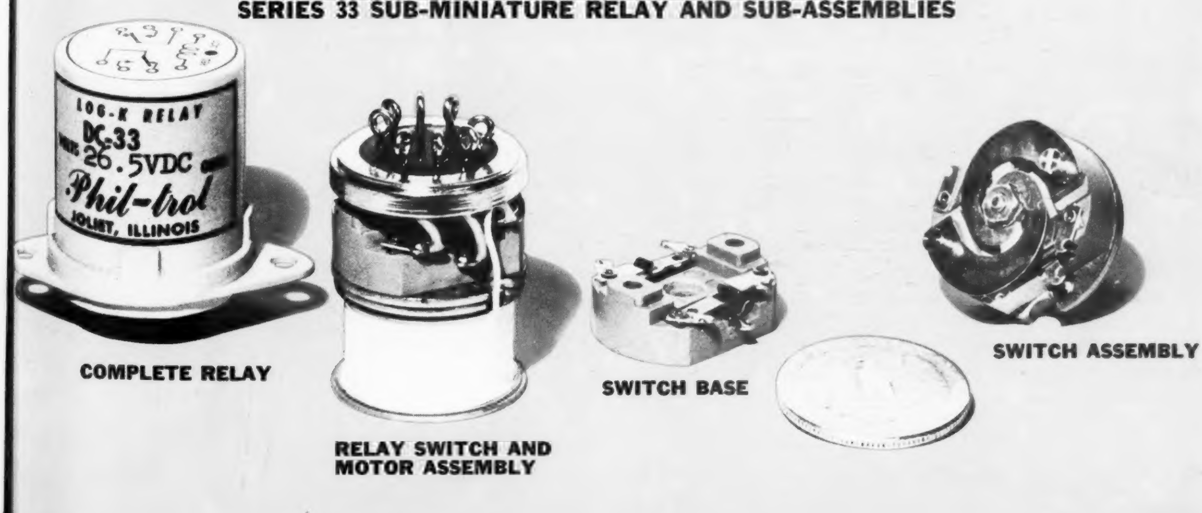
Provisions for mounting are extremely flexible. Rugged standard mounting flange of the encircling type permits placement of flange at any position along body length.

SERIES 33 DESIGN FEATURES:

THE MAGNETIC ASSEMBLY: High magnetic efficiency and unusually low magnetic leakage is a characteristic of this tightly-closed magnetic circuit. Fully annealed Armco iron is used. Favorable armature weight (2.2 grams) to retractable spring ratio accounts for high resistance to external forces. Special coil design—dry-wound without impregnating varnishes and a minimum amount of inorganic materials—provides a high number of ampere turns for greater magnetic efficiency. Freedom of residual magnetism is obtained without use of conventional non-magnetic anti-freeze pins.

DOUBLE SPIRAL SPRING: This unique spring functioning as the armature retraction and one armature bearing, was especially designed for non-resonance over a frequency range from 0 to more than 3500 cps. Composed of two adjacent sections, each of which are dissimilar and tapered by a logarithmic function, this spring cancels out small resonant conditions which tend to occur. Spring is flexible in only one plane, allowing good armature activity plus good armature stability from movement in undesireable planes.

SERIES 33 SUB-MINIATURE RELAY AND SUB-ASSEMBLIES



COMPLETE RELAY

RELAY SWITCH AND MOTOR ASSEMBLY

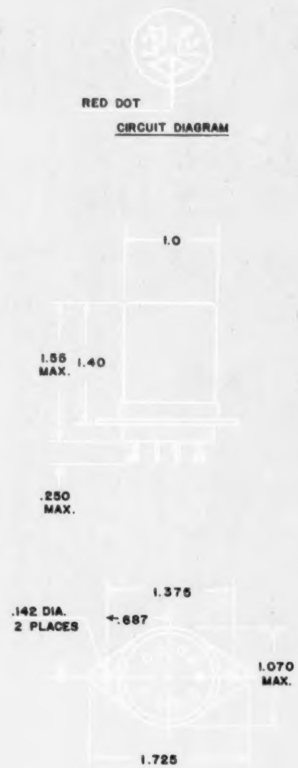
SWITCH BASE

SWITCH ASSEMBLY

Remove and file for reference.

Perforated for easy tear-out.

DC-33	CHARACTERISTICS	DC-33-AC
2 PDT Snap Action-(2 Form C)	**Contact Form**	2 PDT Snap Action (2 Form C)
up to 200v. D.C.	**Coil Voltage**	up to 125v. A.C.
up to 12,500 ohms.	**Coil Resistance**	8,000 ohms.
50G, 11ms.	**Shock (operating)**	50G, 11 ms.
20G to 2,000c.p.s.	**Vibration (operating)**	20G to 2,000c.p.s.
−65 °C to 125 °C	**Temperature Range**	−65 °C to 125 °C
2.5 oz.	**Weight**	2.75 oz.
MIL-R-25018	**Specifications**	MIL-R-25018
Solder or 9 Pin Noval	**Terminals**	Solder or 9 Pin Noval
Standard Relay — available from stock	**DETAIL SPECIFICATIONS**	Standard Relay — available from stock
32	**Max. Operating Voltage**	125 A.C.
26.5	**Nominal Coil Voltage**	117 A.C.
18v. Max.	**Pick-up Voltage @125 °C**	105v. A.C. Max.
13v. Max.	**Drop-out Voltage @125 °C**	50v. A.C. Max.
275 ± 10% ohms.	**Coil Resistance @25 °C**	8,000 ± 10% ohms.
Silver	**Contact Material**	Silver
5 amps.	**Contact Rating, Resistive**	5 amps.
100,000	**Minimum Operating Life**	100,000
Continuous	**Rated Duty**	Continuous
8ms.	**Operate Time**	10ms.
3ms.	**Release Time**	3ms.
.05 ohms Max.	**Contact Resistance**	.05 ohms Max.
1,000 Meg. Min.	**Insulation Resistance**	1,000 Meg. Min.
1,000 RMS	**Voltage Insulation**	1,000 RMS
	Operating Frequencies	60 to 400 c.p.s.



It's Alpha and Beta—Not Sputniks—From Now On

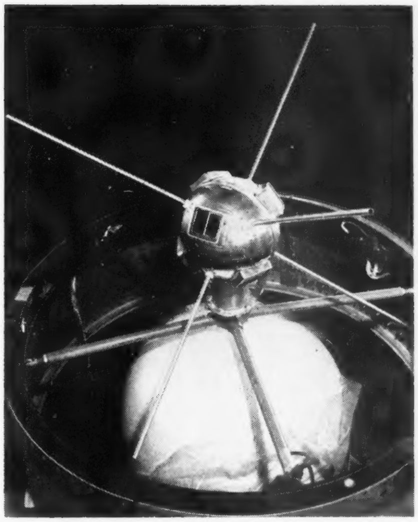
From here on in, Alpha and Beta are the names for satellites. The new terms, an extension of the astronomical system used to identify newly discovered natural objects in the sky, will henceforth be applied to artificial satellites.

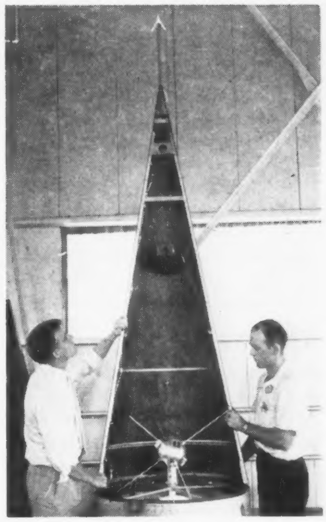
Under this system, the first satellite seen in 1957 would become 1957 Alpha and the second, 1957 Beta. In a further development of this system, Arabic numerals would be used to designate objects according to their apparent brightness. Thus, the Sputnik I rocket becomes 1957 Alpha 1; the satellite itself, 1957 Alpha 2; and the third and faintest object associated with the first satellite (probably the nose cone), 1957 Alpha 3. In like fashion, Sputnik II or Muttnik I becomes 1957 Beta 1.

This may be logical, but, as one observer noted, "it sure lacks color."

National Model Missile Association Organized

A nationwide amateur rocket group called the Model Missile Assn. has been organized under the sponsorship of Model Missiles, Inc., of Littleton, Colo. The association offers senior and junior memberships, and is formulating a Model Missile Safety Code. Arrangements have been made to establish a Test Center on a full square mile of empty land west of Denver, where model rocket shoots will take place under adult supervision and control.





Substitute Satellite

This is the 6.4 in. baby satellite U. S. had hoped to launch last month in place of the initially planned 22-in. "moon" in an effort to beat their March deadline into space.

Looking somewhat like a shrunken head from outer space, the baby satellite weighs 4 lb and, like its larger brother, will sit atop a separation mechanism above the third-stage solid rocket motor. The flexible cross bars between the satellite and the rocket (above left) give support to the third-stage engine before it is spun up and out from the second stage. The crossbars themselves are then ejected after the third stage leaves the protective cylindrical sleeve some 300 miles above the earth.

The nose cone (above right), which will protect the satellite in its ascent through the atmosphere, is made of a temperature-resistant asbestos phenolic compound and is formed in two sections. These sections open up like a clam shell and are ejected once the vehicle has passed through the denser part of the atmosphere.

Missile Market

(CONTINUED FROM PAGE 52)

term news prospects. Among them are . . . aircrafts and missile issues such as *Boeing, General Tire, Martin, Douglas* and *North American Aviation*." (E. F. Hutton & Co.)

Marquardt—"Earnings per share are expected to increase to $1.40 this year, from $1.18 last year. . . . The promising outlook for ramjet engines and the strong representation in this field enjoyed by Marquardt would seem to justify the appraisal of current earnings at about 20 times. The stock . . . has attractive long-term appreciation possibilities." (Fahnestock & Co.)

G. M. Giannini—"While 1957 earnings of about $1.00 per share will fall short of earlier estimates . . . Giannini is bound to be an important beneficiary of the expanded missile program . . . with well over 50 per cent of its sales going directly to the manufacturers of guided missiles." (Forbes)

"*North American Aviation* and *Thiokol* seem to be two issues in the defense group which appear interesting at this time." (Pershing & Co.)

Morris Cohon & Co. has a 23-page study on *Mine Safety Appliances Co.* which, it believes, will benefit materially from the research push in high energy fuels through its 75 per cent ownership of the common stock of *Callery Chemical Co.*

Financial Briefs

. . . *General Dynamics* net for 9 months ended Sept. 30 climbed to $3.50, from $2.51 the previous year, on a 58 per cent increase in sales. (Included in last year's figure was a nonrecurring item of $0.24 per share.) Backlog exceeds $1.7 billion. . . . *Lockheed* official says net this year will slip under the $5.10 a share earned in 1956. . . . *Reaction Motors* sees 1957 earnings at about the same as last year ($1.43 per share) on a 50 per cent increase in sales. . . . *General Precision Equipment* nets $2.70 *vs.* $1.21 in latest nine months period, sets present backlog at $164 million. . . . *Boeing* expects to report slightly higher earnings for 1957, paid 4 per cent stock dividend Dec. 17. . . . *Sperry Rand* earnings decline to $0.62, from $0.70, in 6 months ended September, attributable to increased expenditures for research and development. . . . *North American Aviation* earns $4.22 *vs.* $3.59, in year ended September. . . . *Bendix* expects sales and earnings to decline between 5 and 10 per cent in fiscal year ending next September. . . . *Raytheon* believes sales can reach the $300 million annual level, on which earnings could run around $3 a share, before present capitalization would have to be altered.

people in the news

Truax Awarded Legion of Merit

Protocol officer reads citation accompanying award of Legion of Merit to Comdr. Robert C. Truax (right) as Brig. Gen. O. J. Ritland, who presented the award, looks on.

APPOINTMENTS

S. K. Hoffman, general manager of the Rocketdyne Div. and a member of the National Board of ARS, and **Joseph G. Beerer,** general manager of the Missile Development Div., have been named vice-presidents of North American Aviation, Inc.

Food Machinery & Chemical Corp. has expanded its rocket development activities by establishing its Special Projects Branch as a central chemical function and naming the head of the group, **Noah S. Davis,** past president of the American Rocket Society, to the new position of director. **John H. Keefe** will be manager of the Chemical Dept. and **Erik Saller** manager of the Engineering Dept. within the Branch. Laboratories and test cells for the Branch have already been established in a newly acquired building in Buffalo, N. Y.

Davis

Willey

G. T. Willey, vice-president of manufacturing, The Martin Co., has assumed additional duties as vice-president and general manager of a newly created division designed to speed on-the-spot arrangements for launching of the Vanguard satellite and the AF Titan ICBM. The division will have equal status with Martin's Baltimore, Denver and Orlando Divs., and Willey will have charge of all company activities in the Patrick AFB and Cape Canaveral area.

C. D. W. Thornton has been named director of research and development, Farnsworth Electronics Co. He was formerly director of research, having joined the company in February, 1956, as assistant to the president for atomic energy.

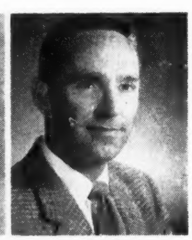
J. G. Tschinkel has joined the High Energy Fuels Organization of Olin Mathieson Chemical Corp. Dr. Tschinkel, formerly head of the Combustion and Fuels Laboratory at the Army Ballistic Missile Agency, is heading a group at the company's laboratory in New Haven, Conn., doing research in the gas generation, combustion and rocket propulsion fields.

Walter C. Robertson has become a vice-president of American Bosch Arma Corp., in charge of marketing and servicing of defense products, as well as contract administration connected therewith.

A. D. Kafadar, formerly manager of the engineering thermodynamics and weapon development group at American Machine & Foundry Co., heads the newly formed Ordnance Engineering Associates, Inc., which will do R&D work and manufacture cartridge-actuated devices for escape capsules and missile applications, and weapons and missile systems components.

The National Science Foundation has appointed **Burton W. Adkinson** head of its Office of Scientific Information. Dr. Adkinson was formerly director of the Reference Dept. of the Library of Congress.

Sinclair



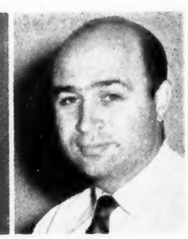
Black

George W. Sinclair has been named plant manager and **John W. Black** assistant plant manager of the Tucson, Ariz., facility of Hughes Aircraft Co. Sinclair was formerly works manager of the plant, which produces the Falcon missile, while Black was associate director of the Hughes Guided Missile Laboratories.

Higginson

Wilhite

Kelley



Guzzo

Thiokol Chemical Corp. has announced five appointments in its new Utah Div., engaged in research, development and testing of large solid propellant engines. **John Higginson** has been named general manager; **V. H. B. Wilhite,** technical director; **A. T. Guzzo,** head, Manufacturing Dept.; **W. D. Kelley,** head, Quality Control Dept.; and **J. E. Dieter,** head, Administrative Dept.

Donald W. Douglas Jr. has been elevated to the presidency of Douglas

Aircraft Co., succeeding his father, **Donald W. Douglas Sr.**, who remains chairman of the board and chief executive officer of the company. **Frederic W. Conant** has been named to the new office of vice-chairman of the board, while **John A. Dundas** has been appointed executive vice-president and named to the board, and **Gen. Ira C. Eaker** (USAF-Ret.), who joined the company in October, has been elected vice-president in charge of the Douglas Eastern offices.

Wisenbaker **Ashworth**

T. C. Wisenbaker has been named assistant manager of the Missile Systems Div., Raytheon Mfg. Co. He was formerly manager of Raytheon's Bristol, Tenn., plant. Succeeding him as manager of the Bristol plant is **H. T. Ashworth.**

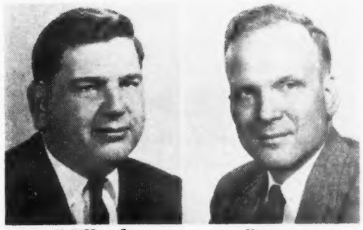
Cambel **Lightfoot**

Ali B. Cambel has assumed the chairmanship of the Mechanical Engineering Dept. at Northwestern University. Dr. Cambel, an Associate Editor of JET PROPULSION, has been at Northwestern since 1953 and is director of its Gas Dynamics Laboratory.

Jackson K. Lightfoot has been appointed chief engineer of the Missile Products Div. of Beckman & Whitley, Inc. He was previously chief engineer of Omark Industries.

William R. Millard has been named head of the Engineering Dept. and **Lewis A. Barry** of the Development Dept. of the Research and Development Div., Callery Chemical Co. In addition, **George P. Brandt** has been appointed production manager of the new Callery plant at Lawrence, Kan.

Lockheed Missile Systems Div. has named three staff managers in the project systems branch. **E. R. Proctor** heads the schedules and coordination staff, **Karl J. Wein** the support



Millard **Barry**

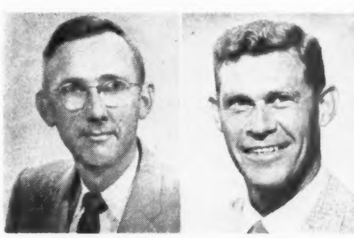
systems staff and **Harry Windsor** the logistics staff.

Atlantic Research Corp. has added four new engineers to its staff. **Joshua S. Bowen Jr.** and **Carl L. Howell Jr.** join the chemical engineering group, while **Robert H. Twyford** joins the missile engineering group. **Humphrey J. Elliott Jr.** has rejoined the company as a member of the project engineering group.

William J. McBride Jr., former manager of Varian Associates' Klystron Development Dept. has been named head of the company's newly formed Systems Group, a separate operating unit which combines the former Systems Development and Linear Accelerator groups.

Walter R. Dornberger has been named technical assistant to the president of Bell Aircraft Corp. Dr. Dornberger, commander of the German Peenemünde rocket station in World War II, joined Bell in 1950 after serving three years as a missile consultant to the AF Air Material Command at Wright-Patterson AFB.

Daniel Breedon has been named staff assistant in the Army Missiles Dept. at Aerophysics Development Corp. He was formerly at Redstone Arsenal, where as an Army Major, he was deputy chief of the surface-to-surface missile branch, Research and Development Div.



Brandt **Breedon**

Ramo-Wooldridge Corp. has established an autonomous operating division called the Space Technology Laboratories. **Simon Ramo** will relinquish his duties as executive vice-president and secretary of R-W to become president of the laboratories. Other officers will be **Louis G. Dunn**, executive vice-president and general manager, and **Ruben F. Mettler**, assistant general manager.

Irvin D. Black has joined the airframe propulsion and internal systems department and **Louis Strauss** has been named manager of the control systems department of Lockheed Missiles System Div. Black will work on Polaris development, while Strauss will direct control systems development for the Navy ballistic missile.

HONORS

Comdr. Robert C. Truax, outgoing President of the AMERICAN ROCKET SOCIETY, was recently awarded the Legion of Merit for his performance of outstanding services in pioneering and advancing Navy efforts in the field of guided missiles. Comdr. Truax, presently attached to the AF Ballistic Missile Div., Hq ARDC, Inglewood, Calif., received the award from Brig. Gen. O. J. Ritland, Vice-Commander of the Division. He was also cited for his performance of duty from 1953 to 1955 as head of the Ship-Launched Branch of the Bureau of Aeronautics and in other capacities, during which time he made an independent study on "Making the Guided Missile Submarine a Primary Naval Weapon," which contained most of the elements of the Navy's current fleet ballistic missile program.

Wolfgang B. Klemperer, chief of the missiles research section of Douglas Aircraft Co., has been awarded the honorary degree of Doctor of Technical Sciences by the Institute of Technology in Vienna, Austria, for his "pioneering and internationally recognized research work in the field of aeronautics."

The Distinguished Service Medal was recently awarded to **Maj. Gen. Albert C. Boyd,** who voluntarily retired Oct. 31 after 30 years in the Air Force. Gen. Boyd, who was Deputy Commander for Weapon Systems of the Air Research and Development Command at the time of his retirement, was cited for his outstanding contributions in the advancement of aircraft testing methods during his assignment with ARDC.

The Lockheed Management Club of Georgia, made up of 2800 men in Lockheed Aircraft Corp.'s Marietta Div., has been named the best in-plant management club in the nation for 1957 by the National Management Assn. Runners-up were the **Convair Management Club,** Ft. Worth, Tex., Div., and the **North American Aviation Management Club,** Columbus, Ohio.

Aspects of Vanguard

(CONTINUED FROM PAGE 47)

sure in the third stage to a very low value while maintaining good combusbustion efficiency. However, this has raised problems of nozzle design, since the correct expansion ratio must be obtained if the desired specific impulse is to be realized. Some question has arisen as to whether the nozzle could absorb the heat flux of the exhaust flame and still maintain its integrity in vacuum, since no cooling is possible except by radiation, and this is limited, being a fourth power of the temperature. Computation and some experiments have shown, however, that the nozzle is not likely to deform during the lifetime of third-stage combustion.

Other Propulsion Factors

Many other propulsion factors are unique to the Vanguard vehicle and can only be listed briefly. Among these are:

1. Thrust alignment and gimballing of first- and second-stage thrust chambers. Since these chambers exercise pitch and yaw control for their respective portions of the vehicle, it is necessary to design a gimballing apparatus with hydraulic actuators, while maintaining close thrust alignment through the center of the vehicle.

2. Mixture ratio control and outage. Flight performance of the vehicle is predicated on a low value of propellant outage. In other words, the liquid rockets must consume almost all their propellants to achieve their mission. Outages can be reduced to low values by a high "hydraulic rigidity," i.e., by having high pressure drops throughout the system and high chamber pressures. Also, some outage control can be achieved by means of a *mechanical* mixture ratio control using proportional propellant valves which can meter the propellants for the proper mixture at all times, and by the use of elaborate turbine speed governors and hydraulic feedback circuits which keep the flow of propellants at the proper volume. It has not been possible to do this in the first stage. The second stage, being a simple gas-pressurized system, is affected by the vagaries of flight, and depends on the ability of the chamber to operate at a given mixture ratio to achieve a reasonable outage while maintaining the necessary combustion efficiency.

3. The third-stage unit must be aligned very precisely to maintain close control of the thrust developed in the nozzle. This unit must also be spun to achieve some "bullet" stability in its flight path in the orbit.

4. All of the tanks and the third-stage case must be designed to withstand high accelerations and yet be light enough to have the required mass ratio. This has required the use of materials stressed to very high values, introducing new problems of welding, fabrication and material control.

Separation Is Complicated

5. The first and second stages must be separated at a high altitude and in vacuum. This cannot be done by magic but necessitates an elaborate scheme of explosive bolts and metal separation. The first-stage chamber must decay smoothly and the second-stage chamber must ignite while this separation scheme is being initiated and completed. The ignition of the second-stage engine is a difficult enough problem in vacuum without the additional encumbrance of ignition in a partially closed area of the second-stage separation department.

Such rocket vehicles as the Aerobee, Corporal, TV-2 and Viking had many problems, of course, but few of those listed above at once. The thrust chamber of the Viking, for instance, ran at a low combustion efficiency with a specific impulse barely exceeding 200 sec. Therefore, there was no serious heat rejection problem. These vehicles had outage difficulties but were not so dependent on reduced outage for ultimate performance.

In the Vanguard, however, the final stage either achieves an orbit or it does not. In the Viking, it was not catastrophic if the rocket missed its hoped for altitude by 20 or 30 miles or so. It was not necessary to ignite engines at altitude nor was there a need for the peculiar interdependence of engine shutdown decay and ignition of various stages as in Vanguard.

Another fluid mechanical problem almost impossible to predict, namely sloshing and cavitation and propellant pipe intake "starvation," is of more concern to Vanguard designers than it was to designers of these other vehicles. Even if propellant sloshing could be predicted and measured, it would be most difficult to do anything about it. Tank baffles, serrations and high pressure drops help reduce this effect but introduce extra weight and complexity which could not be tolerated here.

Variation of Thrust Coefficient

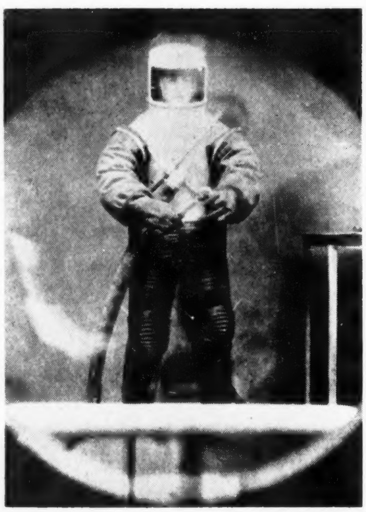
Another question is the variation of the thrust coefficient with altitude for the various Vanguard stages. Certain thrust coefficient values are assumed and, when incorporated in ballistic equations, give a certain altitude or vacuum performance. However, this thrust coefficient cannot be measured accurately at sea level because the second- and third-stage nozzles are overexpanded for sea level pressure. Therefore, the value is much reduced at sea level and has to be extrapolated to altitude.

To conclude, then, the success of the Vanguard propulsion system depends on the achievement of high specific impulses, expected altitude performance and the maintenance of adequate thrust-to-weight ratios without excessive accelerations, high altitude reliable ignition without "hard starts," and a smooth and rapid sea-level engine start so that a good thrust-to-weight ratio may be achieved quickly. If the thrust-to-weight ratio is less than unity or even unity for an appreciable time, not only will unnecessary propellant loss occur, but vehicle stability will be affected, especially if excessive wind velocities are encountered.

The magnitude of the problem can be judged from even this brief description of what is involved. Some, if not all, these factors have been met in one form or another in various vehicles, but never at one time, as in Vanguard.

Solving such problems represents a major step forward in the propulsion field.

95 Miles Up



Neils Jensen, project engineer with Litton Industries, Inc., Beverly Hills, Calif., shows how he can handle a wrench while wearing a pressure suit designed to protect him at a simulated altitude of 95 miles in the new high-altitude test chamber designed by Litton for ARDC.

the international scene

News from abroad about rocket and missile activities

BY ANDREW G. HALEY

The legal problems involved in the use of radio frequencies for space communications will receive international attention as a result of the filing by the American Rocket Society of comments in the legislative inquiry presently being conducted by the Federal Communications Commission preparatory to the next world-wide telecommunications conference to be held in Switzerland in 1959. As General Counsel of the Society, I filed the document with the FCC on Nov. 25, in response to the Commission's inquiry into "What changes in the International Table of Frequency Allocations are required" in the future.

At present, no radio frequencies are set aside solely and specifically for use in connection with the flight of vehicles in space, or for fixed point-to-point communication between earth and positions in space, such as the moon. The U.S.S.R. has proceeded nevertheless to use the frequencies 20.005 mc and 40.002 mc for its Sputniks.

Used for Other Purposes

The 20.005 mc frequency is allocated to the standard frequency services for world-wide use. These services are principally aids to calibration of scientific equipment. The 40.002 mc frequency is allocated for fixed and mobile services in Regions 1 and 2 of the world as established by the International Telecommunications Union; in Region 3, it is allocated to the fixed, mobile and aeronautical radionavigation services.

Improper use of either frequency could result in interference to vital calibration services and to the aeronautical radio and radar services. Thus, a direct threat to the safety of life and property could arise from improper use of the frequencies.

* * *

The U. S. has specifically "cleared" the use of two frequencies—108 and 137 mc—with the nations of the world through the IGY and the ITU. The U.S.S.R. did not request or obtain clearance for the frequencies used by the Sputniks prior to the launchings. In fact, notice of the use of the frequencies was not given until a matter of a few days before the launchings.

Accordingly, the American Rocket Society has stressed to the FCC that the current use of any part of the spectrum for space flight communications "is not primary or exclusive, or, indeed, in some instances, even lawful."

The Society will present its case primarily through the testimony of 17 experts whom we will request to appear before the Commission. Some of the proposed witnesses supplied statements for use in comments as to frequency needs and requirements for antenna design, research on the effects of the ionosphere on radio signals, power supply for transmitters in space, and equipment design.

In reviewing the Society's comments, the Washington, D. C. *Evening Star* on Nov. 29, referred to the document as the "first positive development in the evolution of law for outer space." The newspaper further stated that ". . . this development, coupled with future expectations, may have considerable significance for the early crystallization of regulations for near space."

* * *

Until recently, there has been some reluctance, almost approaching hostility, to the consideration of plans for regulation of radio frequencies for use in space travel. In November, 1956, I traveled to Warsaw, Poland, to propose joint activity between the International Radio Consultative Committee (CCIR) and the International Astronautical Federation. I proposed that the CCIR undertake a review of the requirements of space travel for radio frequencies, and promised the cooperation of the IAF in this endeavor. The CCIR did not agree to the joint effort at that time.

Proposal Has Been Circulated

I am gratified to note, however, that R. Silberstein, Chairman, Working Group F of the USA Study Group VI (which is preparing the U. S.'s recommended CCIR position for submission at the 1959 world telecommunications conference) on Nov. 21 circulated to members of his committee a far-reaching proposal for radio allocations to space flight projects.

This group specifically finds that "observations of radio emissions of the first earth satellites have already yielded valuable information about the ionosphere, as well as about problems of space travel." Accordingly, Silberstein's group is prepared to recommend that "clear channels be set aside for the use of satellite and space ship emissions." CCIR will also be urged to provide for "a carefully controlled comprehensive plan for sharing the standard frequency guard bands for satellite and space ship emissions. . . ."

* * *

With characteristic kindliness and statesmanship, the Prince of Hanover concluded our joint lecture tour on "Law of the Age of Space" with the following statement made at a dinner given by the Greek Ambassador on Friday evening, Nov. 29:

"It is with a sense of sincere gratitude that I have received the invitation which Your Excellencies have extended tonight to Mr. and Mrs. Haley and myself.

Gave 25 Lectures

"Mr. Haley and I have made a most interesting and pleasant journey through the U. S. In 25 different places we have given lectures on the legal problems of space. We have paid visits to the Law Schools of the University of Detroit, University of Michigan, University of Chicago, Northwestern University, University of Wisconsin, University of Minnesota, Montana State University, Gonzaga University, University of Washington, University of California, University of Utah, University of Colorado, St. Louis University, Harvard University, and other campuses, including Princeton University, and always under the distinguished auspices of Sections of the American Rocket Society.

"Everywhere we have found the same marked degree of openmindedness, and the firm resolution to cooperate closely with us in Europe. If this tour of ours has helped to impress a large number of Americans with Europeans' readiness to cooperate with the U. S., then I for one will be most happy.

"I know that the advancement of international scientific cooperation is one of the chief motives of the many travels undertaken by Mr. Haley to Athens, and also to India and to the Middle East.

"It is, therefore, my heartfelt desire to thank you for giving us an opportunity to celebrate here in your Embassy tonight the conclusion of our lecture tour. I wish to express my most sincere thanks to Mr. Haley for his efforts."

Human Factors

(CONTINUED FROM PAGE 43)

At Wright-Patterson AFB near Dayton, Ohio, the Aero Medical Laboratory is studying design problems arising from group confinement for long periods of time. A mock-up NB-36 crew compartment has been modified into a five-man compartment with two independent areas, one for work and one for leisure. The duty area simulates a flight deck where crew members sit in individual ejection capsules. When not on duty, crew members relax in the leisure area. The crew remains in the confined compartment, with no visual contact with the outside, for 120 hr of simulated uninterrupted supersonic flight on a global mission. Psycho-physiological data are collected during the confined period.

Lockheed Aircraft Corp., in Marietta, Ga., under an AF contract, is also studying human factor problems arising from confinement of air crews to a small flight station for extended periods of time. The study is being conducted by the Human Engineering Dept., of Lockheed's Military Operations Research Engineering Div. A mixed discipline of experimental, physiological, social and clinical psychologists, human factors engineers, electronic engineers, industrial designers, biophysicists, endocrinologists and physicians make up the project team. Five crew members spend 120 hr in a simulated flight station which is approximately 17 ft long and 7 ft wide, with an average of less than 6 ft headroom. The present study deals primarily with human behavior under confinement, and will provide information concerning the relationship between performance and physiological states.

Conducted Preliminary Study

The Engineering Dept. of Douglas Aircraft Co., Inc., Tulsa, Okla., has conducted a preliminary study on hermetically sealed cabins and concluded that the state of the art permits the formulation of a research and development program in this field. Such an R&D effort would furnish the aircraft industry with design criteria, fabrication techniques and safety factors for sealed cabin structures of future high-performance operational aircraft, as well as manned rocket ships and space vehicles. In addition, R&D in this field would accomplish reduction of weight through miniaturization of environmental systems and other components in the cabin, thereby making it suitable for airborne use.

True design criteria for any component or system must include the human element as a part of the system. The human factor must be compatible with an individual system and the concept as a whole. A complex hermetically sealed environmental cabin is no better than its weakest link, i.e., the human element, the structure, the environmental unit, electronic controls or other systems or components. A complete program will have to include an extensive dynamic testing phase, which would simulate the most important conditions encountered in operational use of sealed cabins. The human would be an intricate part of these tests. The Douglas Tulsa Div. has test facilities which could be adapted for use in sealed cabin R&D work.

The Douglas-Tulsa high-altitude chamber is bell-shaped, has a 22 ft inside diam, and can be raised on three hydraulic rams 12 ft off the floor. The chamber is actually 33 ft high, including above and below floor levels. The top half is 17 ft 5 in. in height, and weighs 35 tons. The bottom section contains chamber heat exchangers and blowers, and is embedded in the floor. The top of the lower section is level with the floor and has a stainless steel grating capable of supporting 200 psf, or four 1200-lb concentrated loads. The inside walls of the chamber are covered with a 6-in. insulating layer.

The photo of the chamber on page 42 shows an ECM compartment from a Douglas B-66 aircraft, being dynamically tested with all its components and systems inside. The photo also shows the master console for automatic or manual control of any programmed flight, i.e., altitude from 0 to 120,000 ft and temperature variations from +250 to −85 F.

Using the barometric condenser and steam jet system, the chamber can be evacuated to 70,000 ft (0.649 psi) in 5 min, to 100,000 ft in 14 min and to 120,000 ft in less than 30 min. The chamber can be repressurized at a fast rate (uncontrolled) by using the emergency dump valve. In this manner, it can be brought in 30 sec from 100,000 ft to ground level. A fast controlled rate of descent can be accomplished by using the ram air supply. In this way, an altitude of 18,000 ft can be reached in 30 sec and ground level in 2 min.

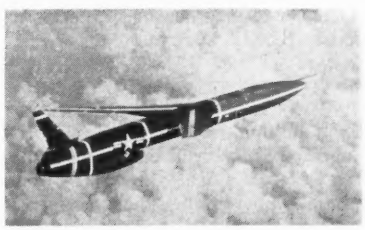
Have Several Advantages

Altitude chambers of this type have a number of advantages in space cabin research and development work. These can be summarized as follows:

1. It is possible to simulate near-space conditions of 120,000 ft (0.0628 psi) indefinitely, without leaving the ground.
2. Tests can include extreme conditions with safety.
3. Chamber tests are less expensive than extensive flight tests.
4. Instrumentation allows an unlimited number of tests to be conducted simultaneously under controlled conditions.
5. Designs can be tested, changes made and retested quickly and economically.
6. The space cabin can be control tested as an integrated unit which includes the human being.

The ideal hermetically sealed space cabin must be a closed self-contained system. The cabin should have zero leakage of atmospheric gases at pressure differentials up to 14.7 psi. The structure must withstand repeated and prolonged exposures to a pressure differential of 14.7 psi with safety. The environmental unit should attempt to simulate the most favorable sea level conditions on the earth, i.e., maintain total atmospheric pressure of 14.7 ±2 psi; oxygen concentration of 30 per cent ±10 per cent; nitrogen concentration of 70 per cent ±10 per cent; carbon dioxide concentration of 0.03 per cent; keep noxious fumes or gas concentrations below detectable levels, e.g., carbon monoxide from smoking (maximum 0.005 per cent); temperature at 70 F ±10 F., and relative humidity at 35 per cent ±10 per cent.

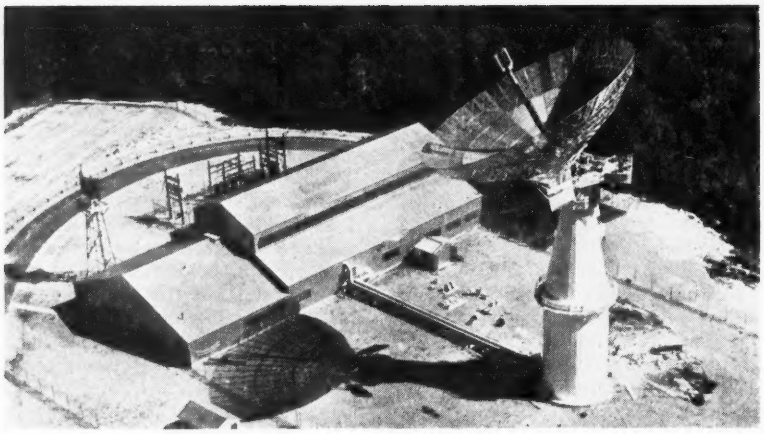
Slow but Sure Snark



On Oct. 31, an Air Force Snark took off from Cape Canaveral, flew for 5000 miles, and delivered its potential nuclear payload "with unprecedented accuracy" on a target near Ascencion Island.

Somewhat akin to the tortoise in the fable of the tortoise and the hare, the subsonic Snark is considerably slower than the upcoming Atlas and Titan, but it is in the air and can fly 5000 miles.

The AF has also announced that Snarks are currently being launched with under-wing auxiliary fuel tanks to provide still greater range for the nation's first operative intercontinental missile.



WESTFORD RADAR: 90-ton "cereal bowl" mounted on a 90 ft high tower.

Antimissile Radar in Operation

Lincoln Laboratory of the Massachusetts Institute of Technology recently revealed the existence of an extremely large and powerful new radar system in Westford, Mass.

Developed in support of the joint U. S.-Canadian program aimed at providing an antiballistic missile defense for North America, the Millstone radar uses powerful klystron tubes 11 ft high to provide the transmitting power, and an antenna system which consists of an 84-ft diam parabolic reflector, mounted on a concrete and steel tower 90 ft high.

The rotating portion of the antenna weighs 90 tons and can sweep the sky with its horizontal rotating capability of 360 deg and a vertical elevating capability of 90 deg.

The announcement also disclosed that U. S. scientists have been using the new radar to pick up the two Russian satellites.

These conditions should be automatically controlled, with manual override.

Initially, stored liquid oxygen will probably be used. Carbon dioxide can be absorbed chemically by some oxide of an alkali earth metal like Li_2O, although calcium oxide would be better, since it can be regenerated. A green algae system has been suggested as a cabin gas exchanger, but volume, weight, power requirements, etc., make this method impractical at present.

The author's research indicates that CO_2 can be decomposed photochemically, by using ultraviolet radiation and a catalyst, with the formation of some oxygen. However, additional research is required in this field before a useful system could be developed to utilize the free ultraviolet light in space to decompose respiratory CO_2 and return some oxygen to the cabin atmosphere.

Water should be conserved by (1) condensation of respiration and perspiration water in the refrigeration section of the environmental unit, and (2) distillation, chemical purification, filtration and bacterial decomposition of wash water and urine.

Facilities for personal hygiene become more important as flight duration increases. On extended flights a shower facility becomes a necessity, rather than a luxury.

Feeding The Space Men

Food could be in pill, dried, frozen or sealed (preserved by gamma radiation) form. Sealed package food would probably offer the greatest variety and would not require refrigeration. However, additional research is needed in this area.

The problem of weightlessness, a characteristic of orbital flight, will not be resolved until manned satellites are tested. However, adaptation to the state of zero gravity seems possible. Orientation in the space cabin will be important to adaptation. Interior design will have to provide orientation aids in the cabin. Seats could be securely fastened to guide rails on what will be considered the floor of the vehicle. In this way, astronauts could move around the cabin while strapped in their seats. Consideration should be given to adequate and continuous lighting of the cabin so that visual references are available for orientation. Objects like flashlights, tools, pencils, etc., should be secured to the wall or other parts of the interior.

Human engineering design should be used in obtaining maximum utilization of cabin space. The work and rest areas should be comfortable and aesthetically pleasing, and should be provided with adequate lighting.

The human occupants should be considered as periodic monitors of automatic equipment in the space craft. Sensible instrument panel displays and simple positive controls (buttons, levers or switches) should be designed. The general parameters of automatic controls in space vehicles are shown in the box on page 43. While no specific system is implied, it seems desirable to provide automatic take-off and landing, and programmed orbital or powered space flights.

Could Be Radiation Hazard

Direct outside vision through transparent surfaces in the cabin wall is not considered desirable from a structural point of view. It could also prove a radiation hazard to the astronauts. As in the submarine, the space crew could depend on a retractable optical device, such as a periscope, for spatial orientation in addition to other instrumentation, such as radar, T.V., radio, etc.

The human operators would have control prerogatives, i.e., corrections, override and emergency. The multitude of electrical, electronic and mechanical components and systems must have maximum reliability, and hence would require a dynamic integrated test program, as indicated previously.

The space cabin should be considered as the escape vehicle, although for added safety individual escape capsules could be provided. A space suit that could be donned quickly and easily should be made available for accidental or intentional decompression in space and for exploration or repair work outside the space cabin. Protection against accidental decompression caused by a meteorite could be attained through use of double wall construction. In addition, the space cabin hull could be of sandwich construction, with inner and outer layers both capable of withstanding the 14.7 psi differential pressure, and with a self-sealing material between the two layers. This sandwich type hull should also have excellent thermal and acoustic properties. In larger cabins, compartmentation could be used.

The primary particles of cosmic rays are made up of protons, neutrons,

alpha particles and heavy nuclei, and have tremendous penetrating power. The passing of cosmic rays through the entire atmosphere is equal to going through 30 ft of water or a 37 in. thick lead plate. Mass shielding of a space cabin against cosmic radiation is not possible. Most of the primaries have an average energy of 6 billion electron volts (Bev); some are as high as 81 Bev. The high specific ionization of these primaries determines their relative biological effectiveness, i.e., particles of high specific intensity are from two to 10 times more effective per roentgen equivalent physical (rep) than are x-rays, gamma rays or beta particles.

In dealing with cosmic rays, it seems wise to consider an acceptable total accumulated dose, rather than the intensity of the radiation alone. With present knowledge, it is doubtful if the recommended maximum permissible exposure to external ionizing radiation of 300 mr per week would be exceeded in short duration space flights. However, H. J. Schaefer has emphasized the need for better data on the physics and biological effects of the primary cosmic ray beam. Balloon experiments to 125,000 ft are vital, but outer space data is needed for space flight calculations.

The effects of unknown dangers, like cosmic ray primaries, meteorites, solar radiation and weightlessness, on man, equipment and space vehicles must be predicted to build in some degree of safety prior to the first manned space flight.

In striving for an ideal space cabin, human factors engineering attempts to get the maximum efficiency from the man-machine complex, by decreasing as many stress factors which may confront the astronaut as possible. The majority of the human factor problems involved in the development of a safe and reliable space cabin can be anticipated and solved by applying existing knowledge in a comprehensive R&D program.

Pots Posthaste

Helipot Corp., Newport Beach, Calif. has set up a special group, Poco Tiempo, to supply prototype quantities of specially modified precision potentiometers on a 10-day delivery schedule at no added cost. Both single- and multi-turn potentiometers in a wide range of diameters and resistance values are produced by Poco Tiempo. Modifications available include special resistance values, tolerances, linearities, taps, shafts, lids, bushings, ganged assemblies, torque, bearings and rotation.

government contract awards

Aerojet Gets $55 Million Titan Engine Award

Aerojet-General Corp. has received a $55,650,000 contract for propulsion units for the Titan ICBM from the Air Materiel Command. The company has formed a Ground Support Equipment Section for missiles, with M. J. Neder at its head. It is now producing such equipment for the Titan in its test stages.

RMI Gets Contract For Drone Engines

A subcontract for development and delivery of a limited number of liquid propellant engines for the RP-76A target drone was awarded Reaction Motors, Inc., by Radioplane Div., Northrop Aircraft, Inc., prime contractor for the Army drone.

Awarded Study Contract

T. Paul Torda, professor of mechanical engineering at Polytechnic Institute of Brooklyn, has received a $20,700 award from the Wright Air Development Center, Wright Patterson AFB, Ohio, for a study on "Basic Fluid Dynamic Phenomena Related to Combustion Stability." The project includes construction of a rocket chamber with 250-lb thrust, and calls for study of such problems as reverse, downstream and side fuel injection jet units in various combinations, and related effects of nonsteady as well as steady, changes in combustion chamber pressure.

Hughes Lets Contract

Hughes Aircraft Co. has let a $2^1/_4$ million contract to Hamilton Watch Co. for quantity production of airborne signal data recorder equipment, used to test the Falcon missile.

AF Orders Tracking Units

Cubic Corp., San Diego, has announced receipt of a $1.1 million contract extension for production and installation of Secor units used by the Air Force in missile tracking and ranging.

Recording Equipment Ordered

Cook Electric Co., Skokie, Ill., has let a contract in excess of $150,000 to the DataTape Div. of Consolidated Electrodynamics Corp. for magnetic-tape equipment for a missile-range instrumentation system which CE is designing and building for the Navy.

SYNOPSIS OF AWARDS

The following synopsis of government contract awards lists formally advertised and negotiated unclassified contracts in excess of $25,000 for each Air Force, Army and Navy contracting office:

AIR FORCE

Commander, Hq. AMC, Wright-Patterson AFB, Ohio.

Plastic compressor blades for jet engine turbine wheels and test reports, $50,246, **Cincinnati Testing and Research Laboratories,** 316 W. Fourth St., Cincinnati, Ohio.

Transducer, low altitude; transducer, air speed, for service drones, $189,467, **Tele-Dynamics, Inc.,** 32nd and Walnut Sts., Philadelphia 4, Pa.

Hq., AF Cambridge Research Center, ARDC, USAF, Laurence G. Hanscom Field, Bedford, Mass.

Design and development of specialized balloon-borne instrumentation for a balloon carrier system, $48,494, **Wentworth Institute,** 550 Huntington Ave., Boston, Mass.

Hq., AF Flight Test Center, ARDC, USAF, Edwards AFB, Calif.

Time and material contract for special maintenance and services for the LOX, LN2 and high pressure gas system, $53,834, **Red Diamond Construction Co., Inc.,** 447852 N. Fig. Ave., Lancaster, Calif.

Hq., AF Missile Test Center, ARDC, USAF, Patrick AFB, Fla.

Increase in estimated cost and funds allotted, $159,528, **Perkin Elmer Corp.,** Norwalk, Conn.

Procurement of additional equipment, $38,025, **Nems-Clarke, Inc.,** 919 Jesup Blair Dr., Silver Spring, Md.

Increase in funds, $150,000, **Radiation, Inc.,** Melbourne, Fla.

Addition of modification No. IV to ABMA missile service structure No. 1, $60,286, **Noble Co.,** 1860 Seventh St., Oakland, Calif.

Increase in funds, $250,000, **Cubic Corp.,** 5575 Kearny Villa Rd., San Diego, Calif.

Services and materials, high resolution tracking system, $87,570, **Barnes Engineering Co.,** 30 Commerce Rd., Stamford, Conn.

Hq., AF Office of Scientific Research, ARDC, Washington 25, D. C.

Continuation of study of the oxidation of metals and alloys, $31,700, **Princeton University,** Princeton, N. J.

Continuation of research on purification and substructure formation of properties of high purity metals, $64,440, **Franklin Institute,** Philadelphia 3, Pa.

Continuation of research on basic transport phenomena in germanium and indium antimonide, $27,500, **Battelle Memorial Institute,** Columbus, Ohio.

Continuation of research on combustion dynamics, $40,000, **Harvard College,** Cambridge, Mass.

Hq., San Antonio Materiel Area, USAF, Kelly AFB, Texas.

Ultrasonic and dye penetrant inspection of F-102 main landing gear cylinders, $39,050, **Automation Instruments, Inc.,** 7750 Monroe St., Paramount, Calif.

ARMY

Los Angeles Ordnance Dist., U. S. Army, 55 So. Grand Ave., Pasadena, Calif.

Repair parts for Nike system, $395,939, **Douglas Aircraft Co.,** 3000 Ocean Park Blvd., Santa Monica, Calif.

Spare parts for the Corporal missile system, $77,505, **Firestone Tire & Rubber Co.,** 2525 Firestone Blvd., Los Angeles, Calif.

Dart antitank guided missile, $826,963, **Aerophysics Development Corp.,** P. O. Box 689, Santa Barbara, Calif.

Spare parts for Nike system, $110,034; repair parts for Nike system, $819,289, **Douglas Aircraft Co.,** 3000 Ocean Park Blvd., Santa Monica, Calif.

Military Petroleum Supply Agency, Washington 25, D. C.

Jet fuel 4, 5,000,000 gal., **Continental Oil Co.,** 1300 Main St., Houston, Tex.

Office of the District Engineer, U. S. Army Engineer Dist., Baltimore Corps of Engineers, P. O. Box 1715, Baltimore 3, Md.

Furnishing and installing electrostatic precipitator for hypersonic wind tunnel, Aberdeen Proving Ground, Md., $37,370, **Western Precipitation Corp.,** 1000 W. Ninth St., Los Angeles, Calif.

Purchasing and Contracting Div., White Sands Proving Ground, N. M.

Extension of telemetering building at Tula Park, White Sands Proving Ground, N. M., $57,320, **H & Y Construction Co.,** 2500 Federal St., El Paso, Tex.

Redstone Arsenal, Huntsville, Ala.

Hydrogen peroxide, C. P. grade, 76% ±0.1% concentration, $33,876, **E. I. Du Pont de Nemours & Co.,** Electrochemicals Dept., Wilmington, Del.

Furnish and supply 68,800 manhours of qualified civilian instructors to the Ordnance Guided Missile School for use in preparing instructional courses and programs, $306,160, **Philco Corp.,** 22nd St. & Lehigh Ave., Philadelphia 32, Pa.

U. S. Army Signal Supply Agency, 225 So. Eighteenth St., Philadelphia 3, Pa.

Additional services, facilities and materials for 12 months directed toward rocket-borne measurement of temperature and winds in the Arctic, $120,000, **University of Michigan,** Ann Arbor, Mich.

Solid Propellants

(CONTINUED FROM PAGE 41)

However, this accusation hinges on a second argument, the argument that the entire propellant charge must be contained in a pressurized combustion chamber, and therefore light fuel tanks cannot be used. When only the surface aspects of this problem are considered and quantitative examination is not made, this accusation does indeed appear to be quite indefensible. Let us, however, examine the metal thickness necessary in a combustion chamber of a solid rocket engine operating at 400 psi chamber pressure. Let us suppose that this is a fairly sizable rocket with a diameter of 7.5 ft (90 in) and a length-to-diameter ratio of 4 (30 ft in length). Using the standard cylinder strength formula, and assuming a strength of 125,000 psi for the structural material, the wall thickness is

$$t = \frac{400 \times 90}{2 \times 125{,}000} = 0.144 \text{ in.}$$

For a tank of this size, it seems that any further reduction in wall thickness would make the device extremely difficult to handle and to assemble in a missile (even in the empty condition as it might be applied in a liquid fuel rocket). When such a tank is utilized in a solid fuel rocket, it is feasible to eliminate a greater portion of the missile structure by allowing the tank to carry the various aerodynamic loads imposed during flight, as shown in the drawing on page 41.

Wall Thickness Examined

Without a detailed examination of the application, it is probable that the wall thickness of a tank of this size would be established by the aerodynamic and acceleration loads which the missile must withstand, rather than by the internal chamber pressure. On the other hand, if the tank is used to contain liquid fuels of much lower density, and if the ratio of fuel to inert components is kept constant, it would be necessary to reduce its thickness, and therefore its weight, by a factor of at least 1.4. This would result in a tank thickness of about 0.1 in. If such a tank were utilized in a liquid rocket, it seems almost certain that additions would have to be made to the structure to withstand the various types of loads encountered in flight.

Although this comparison cannot be made quantitative without a detailed examination of the particular missile system requirement, it seems that the pressure vessel argument is indeed a weak one, especially when the capabilities of the solid fuel tank can be utilized as a major missile structural member. Further general points favoring solids in this argument are (1) that solid fuels are appreciably more dense than liquid fuels, and (2) whatever excess weight may be necessary in such a pressure vessel can be balanced against the weight of the liquid rocket turbopump, the fuel driving the pump, and the weight of the portioning devices and combustion chamber.

Progress in Thrust Vectoring

The third charge, that solid rockets cannot be adapted to incorporate thrust vector control and thrust termination, can be discussed only indirectly, since the current status of any items of technology pertaining to these questions is under security wraps. While it is not possible to discuss the present state of the art in this area in an unclassified publication, it is obvious that the term "cannot" in the indictment fails to allow for technological progress during the past 10 to 15 years.

Now that the attacks hurled at solid rocket systems have been repelled, we are ready to take the offensive. It will be directed at fundamental deficiencies of liquid fuel systems, and will ignore such practical matters as the long times needed to prepare for launching and other field handling difficulties. We will leave the liquid propellant engines to such applications as high velocity sleds, or possibly, if reliability can be improved upon, to those manned long-range commercial applications in which the expensive engine (a remarkable chemical processing plant!) can be recovered, refueled and reused. The pendulum of development effort has far too long swung preponderantly to the side of the turbopump liquid propellant engine. Our objective here is to give the pendulum a push in the other direction.

Liquid fuel engines are very complex mechanical devices, and require very high reliability of a great number of components which must work in series to achieve reliable system performance. Even though the reliability of individual components may be high, the series reliability of a great number of such components results in a much lower probability of success than is acceptable in most missiles. There is no rebuttal to this argument other than an actual demonstration of liquid engine reliability. The tremendous effort that has gone into liquid engine development in the past has nonetheless failed to produce such a demonstration.

Army's Satellite

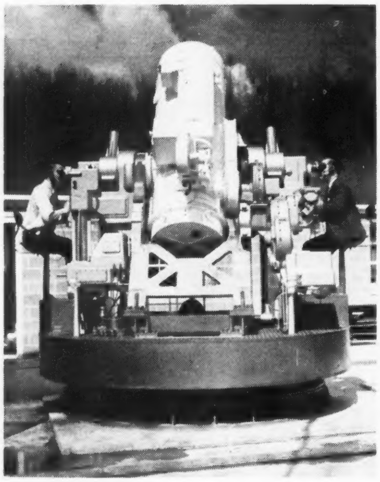
W. H. Pickering, director of the Jet Propulsion Laboratory, California Institute of Technology, holds the 20-lb satellite the Army hopes to launch from a Jupiter-C rocket early this year. The laboratory is building the satellite for the Army.

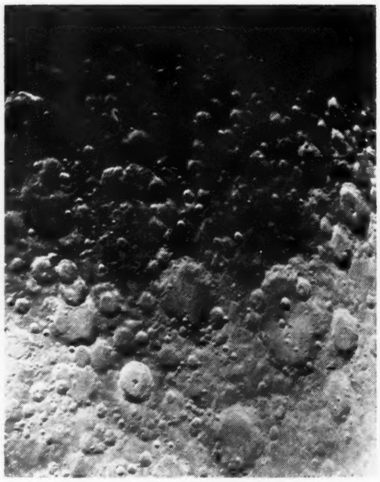
The reliability of large liquid engine missiles is a matter of common knowledge to those who read the newspapers. If you are a collector of such statistics, compare them to the record of the largest solid engine powered missiles yet flight tested. In 40 flights of experimental missiles, there has been one failure partially attributable to the engine, and this was caused by a very simple and easily corrected defect in the material of the pressure vessel.

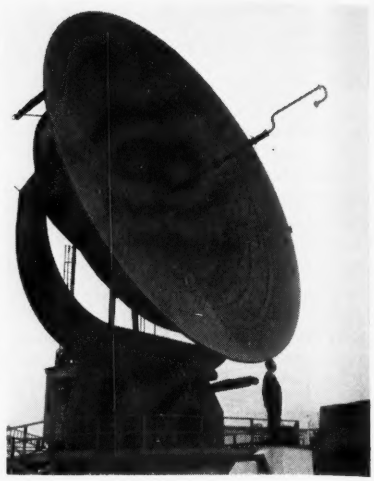
Defects of Turbopump System

Acceptable high performance in liquid engine systems can be attained only by the turbopump system. Unreliability and difficulty of starting are inherent in this system, and for these reasons the system is not readily adaptable either to staging or clustering. The reliability of a single liquid engine is so low that even the most optimistic may quail at the idea of grouping more than a few turbopump systems together into a clustered stage. Ignition during flight, especially in a high vacuum and at zero acceleration, seems to impose Herculean problems that have eliminated the turbopump system from consideration as a second or subsequent stage in most missile systems.

On the other hand, the reliability and ease of ignition of solid rocket engines have resulted in the common practice of clustering "off-the-shelf"







Sight . . . and sound . . . add to scientist's knowledge of the moon.

Shooting the Moon

Tagged ROTI (Recording Optical Tracking Instrument), Perkin-Elmer's new telescopic camera (left) has taken pictures of the moon (center) that, in effect, bring the viewer to within 250 miles of the lunar surface. Essentially a high speed, 70 mm camera mounted behind an 8-ft telescope, the system was developed for Air Force use in tracking long-range missiles. The first unit is now undergoing preacceptance tests at Melbourne Beach, Fla., about 15 miles south of the Air Force Missile Test Center on Cape Canaveral. A second unit will be installed at Vero Beach, Fla.

The other unit (right) is the 600-in. radar telescope that radar astronomers at the Naval Research Laboratory are using to measure distance from earth to moon. The astronomers accomplish this by bouncing high frequency radar signals off the surface of the moon and measuring the time the signals take to reach the moon and return.

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units to provide stage requirements for a particular missile system. Many rockets with three or more stages have been fired at high velocities and high altitudes, and ignition problems or unbalanced thrust have caused no difficulty.

Attainment of High Thrust

The biggest shot (20 megaton!) of our counterattack has been saved for the greatest inherent deficiency of the liquid fuel turbopump system: Its inherent poor capability for attainment of high thrust. Scale-up of the turbopump combustor systems is such a vast problem that we do not have in this country today a liquid engine capable of meeting thrust requirements of some of the large missiles without clustering. The problems encountered in scale-up to higher thrust are so tremendous that even the hundreds of millions of dollars spent in the past on liquid engine development have not left us in a position to make a reliable estimate of what it would cost to double the thrust output of our largest system. When larger thrusts are needed, this problem can be approached only from the standpoint of clustering a number of combustors into a single stage, with the inherent lack of reliability, high cost and high weight penalties for interconnecting and control devices.

Although solid engines can be clustered with a high degree of reliability, attainment of high thrust from a single solid engine is entirely feasible, and, in fact, is the only way that high thrust can be obtained to lift the very heavy loads that will be involved in space travel. Although it is not the intention of this article to design a space ship, it might be advisable to examine some of these loads to develop some feeling of the magnitudes involved.

If we examine the current capabilities of rocket systems based on chemical fuel operation, we come to the conclusion that escape velocities can be attained at a certain linear ratio between payload and missile take-off weight. This linear ratio is dependent upon the quality of the rockets and the state of the art at the time the missile propulsion system is designed. Currently, this ratio may be some place between 100 and 2000 to one, but we might take a reasonably optimistic view and assume that it can be accomplished with a ratio of 1000 to one. If we choose to send a manned vehicle around the moon and to return the occupant alive by an elliptical breaking glide path into and out of the earth's atmosphere, it seems unlikely that this could be accomplished with a payload weight of less than 4000 lb. Applying our linear factor, it would be necessary for the take-off weight of the missile to be at least 4 million lb at the time of launching.

Now let us examine the capabilities of a solid engine to furnish the first-stage thrust necessary to lift such a load.

Scale-Up of Existing Rocket

Starting our scale-up with an existing rocket, let us consider the XM19 (Recruit), used as the second and third stages of the Lockheed X-17. The Recruit rocket is not an optimum design to scale up for such space vehicle propulsion requirements since it was originally designed for a single function, i.e., accelerating an aerodynamic test vehicle to extreme velocities in dense atmosphere. The requirement for thrust-to-diameter ratio was extremely high to overcome drag forces.

On the other hand, the Recruit rocket is indeed a high-performance rocket and is not at all a bad candidate for scale-up to first stage for such a space vehicle. The complete performance characteristics of the Recruit are still classified, but we can examine three parameters:

Diameter	9 in.
Weight	350 lb (approx.)
Thrust	35,000 lb (approx.)

This rocket, like any other solid propellant rocket, is susceptible to linear scale-up, and a very simple set of equations can be used to predict various performance parameters with reasonable accuracy.

Burning Time and Thrust Duration

If we scale up any solid propellant rocket by a linear scale factor of S from Size A to Size B, the duration bears a linear relationship to scale factor of the duration of Rocket B equals S times the duration of Rocket A.

Thrust

In scale-up, propellant composition, operating pressure, burning rate and density are all held constant. The thrust will therefore be in direct proportion to the burning surface. Therefore, the following equation holds:

Thrust of Rocket B $= S^2 \times$ the thrust of Rocket A.

Weight and Total Impulse

Since the weight of the rocket engine and the total impulse of the engine bears a direct relationship to volume, the following equation will hold:

Weight or Total Impulse of Rocket B $= S^3 \times$ weight or total impulse of Rocket A.

Thrust-to-Weight Ratio

The two above equations can be combined to show that thrust-to-weight ratio scales as one over the linear scale factor. In other words:

$$\frac{F}{W} \text{ of Rocket B} = \frac{1}{S} \times \frac{F}{W} \text{ of Rocket A}$$

Now we have enough information to scale up the Recruit rocket to furnish an engine for a large size stage. We note that the thrust-to-weight ratio of the Recruit is 100. Let us then scale up the Recruit by a linear scale factor of 50 to a thrust-to-weight ratio of 2, a value adequate to start a large missile on its trajectory towards space. The thrust of such a rocket will be: $35{,}000 \times 50^2$ or 87,500,000 lb. The weight of such a rocket will be: 350 lb $\times\ 50^3$ or 43,000,800 lb.

This, we note, is 10 times the weight required for the 4000-lb payload we assumed earlier. Now we can send the designer back to the board to incorporate additional protection and safety devices for the crew we expect to send around the moon. With the additional 36,000-lb weight allowance, we might even include another rocket stage to assist in canceling part of the velocity of the vehicle at the time of return to earth.

The manufacturing techniques involved in making such a rocket are quite straightforward, and most of the problems have already been solved. Like the casting of a concrete dam, such a rocket can be made by casting into place successive batches of composite propellant, each one on top of the preceding one. An examination of the physical characteristics attainable in current propellants leaves us with adequate assurances that such a charge could support its own weight against the proposed acceleration, with safety factors that are entirely adequate to assure proper performance. The Recruit rocket scaled up for this example is by no means taken as the optimum design for such calculation. Even better capabilities are available, if required.

Previously a very important figure was used—the guesstimated ratio of take-off weight to payload for an escape velocity missile. This figure is strongly dependent upon powerplant performance. A feeling for the magnitude of this effect may be gained by some very simple calculations. For any rocket operating in a "g"-free, drag-free environment, the velocity per stage at stage burnout may be calculated by

$$V = I_{sp} \times 32.2 \log_e \frac{W_1}{W_2}$$

where I_{sp} is the fuel specific impulse, and W_1 and W_2 are the initial and final weights of the stage. If there were no atmospheric drag and if we could burn all our rocket stages in a very short time, we would need to calculate $v = 37{,}000$ fps for the sum of the stages. To allow some surplus "V" to compensate for atmospheric drag and the action of gravity during burning, a theoretical "V" of around 40,000 fps should be a goal.

The table on page 41 shows theoretical attainable velocities with various assumed engine performance parameters. Calculations were made on the basis of a stage load ratio of 1:4, i.e., the operating rocket engine at the start of operation weighs four times the weight it carries.

Higher Energy Fuels

The ratio of take-off weight to payload attained in Vehicle III is indeed attractive, but probably well beyond the reach of propellants (solid or liquid) based exclusively on a carbon-hydrogen-oxygen propellant system. Fortunately, a provident nature has furnished us with a number of choices of materials with more energy than petroleum hydrocarbons. It is also a notable fact that the great preponderance of such materials occur in the solid form! It is quite probable that even the free radical fuels—the next step towards higher energy—will be stable only in a highly deactivated state. Such a probability implies that free radical fuels, if usable in a rocket, will be usable only as solids.

Perhaps as this is being written, a 20th Century Einstein is completing the final phases of unified field theory, and we will then be able to create force without the need to squirt mass backwards. We can then bring to bear the great potential of our atomic powerplants.

In the meantime, the conquest of space depends upon solid propellants.

ABMA Recruiting Civilians

The Army Ballistic Missile Agency at Huntsville, Ala., has begun recruitment of 400 additional civilian employes. The Agency now employs 4100 Civil Service personnel, engaged in completing the weaponization of the Redstone ballistic missile system and in developing the Jupiter intermediate range ballistic missile. Approximately 800 military personnel are also assigned to the Agency.

Among the categories of skills desired are: Engineers, physicists, mathematicians, equipment specialists, accountants, draftsmen and procurement analysts.

French Announce Three New Research Rockets

The French Ministry of National Defense has announced the successful firing of three new high-altitude research rockets, the Veronique, Monica IV and Monica V.

According to the communique, the improved Veronique can now carry a 120-lb payload to 130 miles, or approximately 90 miles higher than the older version. Other specifications of the vehicle: Take-off weight, 3000 lb; length, 23 ft; diameter, 29 in.; span, 44 ft; maximum altitude, 135 miles; speed (at 20 miles), 43,000 mph; payload space, 4.6 cu ft (enough to carry small animals).

Monica IV, says the Ministry, will carry a 33-lb payload to an altitude of 50 miles. Its specifications: Weight, 270 lb; length, 17 ft 7 in.; diameter, 6.3 in.; maximum altitude, 100 miles; maximum velocity, 3500 mph.

Monica V reportedly will carry the same payload to an altitude of 100 miles. Specifications: Weight, 340 lb; length, 20 ft 6 in.; diameter, 6.3 in.; maximum velocity, 3500 mph.

Designed primarily as research rockets, the Monicas could be easily converted to antiaircraft rockets comparable to the U. S. Nike.

Swedish Engineer Sees Danger from Moon H-Blasts

When SPACE scientists gathered at Barcelona last fall for the Eighth International Astronautical Congress, they expected to hear some rather revolutionary concepts proposed. S. Fred Singer, professor of physics at the University of Maryland, didn't disappoint them. He suggested the moon be used as a target for interplanetary ballistic missiles tipped with H-bombs.

This is going too far, warns Swedish engineer Robert Engström. He notes there is a risk that such a move would sink the earth under a tremendous tidal deluge. While it is strictly theoretical at this point, the risk, because of its ominous consequences, merits intensive study before anyone tries to bomb the moon, Engström points out.

Laudable as Dr. Singer's aims are—"such explosions. . .can tell us a great deal about the environment of the earth, the properties of the interplanetary medium and in general deepen our understanding about the nature of the universe"—Engström feels he has not adequately accounted for the laws of celestial mechanics.

"According to these laws," Engström writes, "angular momentum is indestructible. Thus, the total amount of angular momentum of the earth-moon system remains unchanged, whatever the details of this motion. If the earth's rotation continually is braked by tidal friction, its angular momentum diminishes. To keep the total unchanged, the moon must then increase its angular momentum, and continually recede from the earth, since its angular momentum, i.e., mass $\times$ velocity $\times$ distance from the earth, increases with the square root of the distance.

Similar to Tidal Friction

"If an H-bomb were exploded on the moon, the recoil would move the moon away from the earth, increase its angular momentum and force the earth to decrease its angular momentum. In effect, it would act similarly to tidal friction. But there is one difference. Now it is the earth which has to regulate its angular momentum relative to that of the moon, and it must do it fast.

"A nominal H-bomb at 20 megatons TNT releases 8.6×10^{15} kilogram-meters of energy. Tidal friction is estimated to be 1.5×10^{11} kgm/s. Most of this energy is dissipated into heat, but 3.65 per cent, or 4.73×10^{14} kgm/day, is used to move the moon away from the earth and keep the total angular momentum unchanged. Thus, considering energy distribution and efficiency, a 20-megaton H-bomb would immediately increase the angular momentum of the moon as much as normal tidal friction does in a day."

Might Result in Deluge

If tidal waves had to brake such energy in a few seconds, says Engström, the result would be a mighty deluge on earth.

If this assumption about angular momentum is correct, then Foucault's pendulum (at the poles) should make one turn per sidereal day, he continues. On the other hand, according to ordinary mechanical laws, the pendulum must turn 360 deg per solar day, not per sidereal day.

"The difference between solar and sidereal time is 0.3 per cent," he notes. "During the last 50 years, no precision tests have been made with Foucault's pendulum, and earlier tests agree only to an error of about 1 per cent. Then there is the problem of what absolute and relative rotation means from an energy point of view. The whole relativity theory is based on the Michelson-Morley experiment, which only considers translatory motions.

"If Foucault's pendulum turns according to sidereal time, this would mean that an H-bomb explosion on the moon would most certainly result in a deluge on the earth, but, if it turns according to solar time, the explosion will probably cause no reaction whatsoever in the oceans, or a minimal reaction."

In any case, urges Engström, some scientific center should deliberate upon the risk of a deluge *before* anyone sends the first nuclear bomb to the moon.

Sound Suppressors for Jet Engines Tested

Metal mock-up of a combination noise suppressor and thrust reverser designed by Douglas for the DC-8. When pneumatically retracted, the two sections of the clam-shell reverser return to the normal flight position flush with the engine pod.

Encouraging results are reported by Douglas Aircraft Co. in its top priority program of developing a jet engine sound suppressor for the DC-8 jetliner. Over 3000 tests have been conducted to measure the effect of combinations and modifications of three fundamental suppression methods.

Jet noise is controlled by including a mixing of the jet stream with the surrounding air so that the speed gradient is less violent. Three basic methods to accomplish mixing are: (1) Replacing the single large nozzle with a group of smaller ones; (2) interrupting the uniformity of the exhaust stream by revising the nozzle shape; and (3) adding an ejector tube around the nozzle so that the exhaust itself will become the core of a rapidly moving cold air stream.

Significant gains have been achieved by combining elements of these methods. One design uses flaps around the jet nozzle to diminish noise at take-off, and a clam-shell device to reverse thrust after landing. While much of the development test program has been conducted with 10 and 20 per cent scale models, a number of full-scale models are under test to develop and prove satisfactory endurance and reliability.

J-75 Passes Navy Tests

The Pratt & Whitney nonafterburning J-75 turbojet engine has met or exceeded all of the company's performance estimates, as well as performance guarantees, during tests at the Naval Air Turbine Test Station, Trenton, N. J. The J-75 has been announced as the powerplant for the AF Republic F-105 and Convair F-106 fighter-interceptor types and the Navy's Martin P6M Seamaster. Thrust of the engine as initially qualified has been revealed as 15,000 lb, a figure greatly augmented by use of an afterburner in military configurations.

First Satellite Results

(CONTINUED FROM PAGE 50)

Nevertheless, they add, on the basis of their observations and calculations, they "feel confident to assume" that Alpha 1 is of a shape and empty weight that corresponds closely to the Soviet single-stage, liquid propellant rocket T-1 (M-101), assuming that a forward section of the rocket shell was blown away to free the satellite proper.

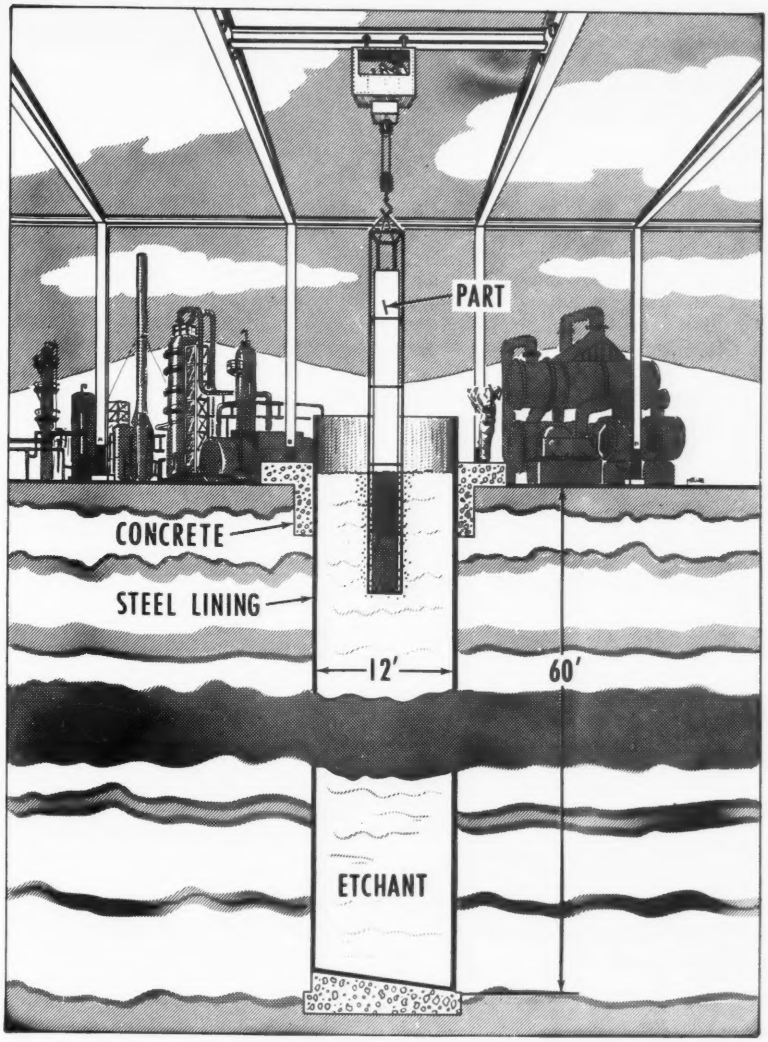
The T-1 is an improved version of the old German A4, better known as the V-2. While the exact specifications of the T-1 are not known, those of the V-2 are. It was 5 ft 5 in. across, 46 ft long and had an empty weight of approximately 6600 lbs. The Smithsonian and NRL scientists "further assume" that Beta is almost identical to Alpha 1 in size and shape.

Indicated cross-sectional area of Alpha 1 and Beta is from 200 to 800 sq ft, while weight is estimated at 2000 to 8000 lb. These basic limits are agreed upon by scientists at both the Smithsonian and NRL observatories, and the T-1 falls within these limits.

Actually, the size and shape of the Soviet satellites are of only secondary importance to the scientists. They are more interested in what the vehicles can tell them about the upper atmosphere, on which there is so little direct evidence. Here, particularly in regard to atmospheric density, they believe the satellite can prove of great value. (For exact derivation of density figures, of course, it is necessary to know, among other things, the size, shape and weight of the vehicles.)

The scientists at the Observatory and NRL have now made preliminary calculations of atmospheric density at 220 and 233 km using ground-based radio, visual and photographic observations of Alpha 1, Alpha 2, and Beta. Again they stress that their results are tentative and based partly on assumption. And again, their results are interesting and somewhat suprising, indicating that the densities at these altitudes are higher than had been thought previously.

Actually, the work of the satellite trackers is just beginning. As more sightings are made and as techniques and equipment are improved, more exact information will become available and more accurate computations will follow. But as far as the scientists at the Smithsonian Astrophysical Observatory and at the Naval Research Laboratory are concerned, it has been a good albeit somewhat hectic beginning. And sitting on the edge of space, these satellite scientists have had little time or inclination to regret their lost sleep.



USCM's TAPERING TANK: Chemicals hit the high spots.

Chemical Milling Goes Underground

Chemical milling, the controlled removal of metal by chemicals, (see JET PROPULSION, April 1957, p. 425) is catching on in the aircraft and missile business in a big way.

Latest unit to go on stream is United States Chemical Milling Corp.'s (Manhattan Beach, Calif.) new tapering tank which was developed to meet the increasing demand for extremely long tapered structures designed for advanced aircraft. The tank, which extends 60 ft underground, is capable of handling parts up to 55 ft long and 11 ft across.

U. S. to Build Big Wyoming Missile Base

The Defense Department has announced that it intends to spend $65 million on the construction of a huge new missile site at Francis E. Warren AFB, near Cheyenne, Wyo.

Air Training Command technical schools now located at the base will be phased out as construction begins next June, and jurisdiction of the base will be transferred from Air Training Command to Air Research and Development Command. It is estimated that 4000 to 5000 personnel will be required to operate the new missile facility.

from the patent office

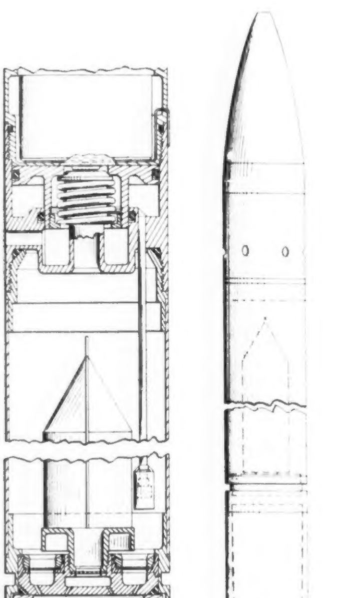
BY GEORGE F. McLAUGHLIN

Feeding System for Liquid Propellant Rocket

Space and weight limitations on small artillery rockets require that the scheme used for feeding propellants to the combustion chamber be simple, light and of minimum displacement. To attain maximum range, all space not occupied by the warhead and the motor must be used for propellant.

A desirable system for feeding propellant is one which rapidly applies a large amount of energy to deliver propellant to the injectors. Heavy turbine-driven pumps are used for this purpose in large rockets, but are unsuitable in small rockets because of their weight. Also, in large rockets it has been feasible to store energy in the form of highly-compressed gases which, upon release, pressurize the interior of the propellant tanks to force the contents into the combustion chamber. However, storage of gases at high pressure necessitates the use of heavy containers which have no capacity for holding propellant, and represent waste space in the missile.

This invention contemplates use of limited amounts of the energy in the propellants to pressurize and force them into the combustion chamber.



Artillery rocket features compact liquid propellant feeding system.

By timely combination of the propellants in limited amounts, and under controlled conditions, the energy is quickly released when pressurization is required, and the propellants are stored at pressures low enough not to require increased tank wall thickness.

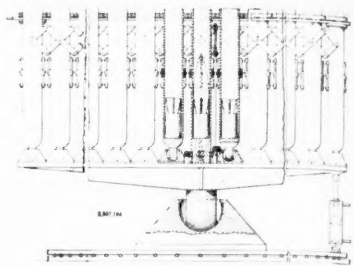
Propellants are contained in a cylindrical tank and in a bag within the tank. A wide variety of liquid propellants may be used of which a typical combination would be white fuming nitric acid and turpentine. The propellant combination may be hypergolic, i.e., self-igniting at ambient temperature and pressure upon contact or mixture, or it may require separate ignition.

The bag may be made of polytrifluoromonochloroethylene (trade name "Kel-F"), which is particularly suited to contain the more active of the propellant pair chosen. For instance, in the case of turpentine and white fuming nitric acid, it is expedient to contain the acid in the bag. Stainless steel or other corrosion-resistant materials may also be used as bag materials, depending on corrosive characteristics of the propellants.

In operation, the bag is filled with one of the propellants. The cylinder is filled with fluid hypergolic with the propellant. When the missile is ready for firing, electrical current is applied, and a powder charge in the chamber is detonated by ignition of the heating element. Detonation causes movement of a piston which forces fluid through a conduit, rupturing a diaphragm in the injector. Ignition occurs on contact of fluid with the propellant. The tank therefore becomes pressurized and the same pressure is transmitted to the fluid. Propellants flow through the injector, and the motor may be fired either by spontaneous combustion or by a separate firing system.

An advantage of this arrangement for containing the two propellants is that the bag may be sealed before assembly of the rocket. This permits storage of the missile in ready condition for extended periods without danger of leakage or combustion because of intermixture propellants.

Liquid propellant rocket (2,789,-505). J. M. Cumming, G. P. Sutton, V. R. Vorwerk, D. B. Harmon and C. A. Villiers, assignors to North American Aviation.



Adjustable rocket launcher varies area and concentration of fire.

Rocket Launching Unit Fires Patterned Salvo

Ground defense against air attack involves placement of antiaircraft batteries in and around a target area. Despite extensive AA fire from conventional weapons, attacking planes are able to penetrate the defenses by employing evasive action, even where fire is controlled by radar.

The launcher described here is designed to fire a salvo of rockets in a fire pattern of such concentration that the effectiveness of evasive maneuvering will be minimized. In this device, launching tubes may be directed as a unit and adjusted to vary the pattern area to meet different formations of attacking aircraft.

The adjustable plate for the launching tubes consists of a base which supports a plate riding on ball bearings and rotated by a gear train. The plate may be selectively tilted from the horizontal by a pivot-mounted hydraulic piston. The bottom ends of rocket tubes are pivotally secured to the plate, a fixed central rocket tube is secured to the plate, and lazy-tongs coupled to and interconnecting the tubes permit guides to swing through a plurality of arcs. Guide actuating means carried in the base plate consist of a shaft journaled to the base and a pair of spacers coupled to one of the lazy-tongs. Gears coupled to the shaft and connected to the spacers transmit motion to the guides.

The inventor claims a devastating barrage may be directed against attacking aircraft by use of the launcher. Impregnable defensive fire is effected if rockets from which cables are suspended are fired. The device can be readily anchored to the ground or to the deck of a ship.

Rocket launching device (2,807,-194). Bruno Cammin-Christy, New York, N. Y.

Lacrosse Maintenance Unit Undergoes Test Training

The first Lacrosse guided missile maintenance unit is undergoing test training at the U. S. Army Ordnance Guided Missile School, Huntsville, Ala. Known as the 572 Ordnance Detachment (Guided Missile Direct Support, Lacrosse), with an authorized strength of 30, the unit is being used as a pilot for future outfits of this type. The 572 is serving to develop a recommended course of instruction for Lacrosse support units at OGMS. In addition to the Lacrosse, the school offers Nike, Corporal and Redstone courses.

Regulus II Gets Rocket Assist

Moving another step closer to fleet operation, the Navy's Regulus II recently underwent its first test firing using a rocket booster. The test took place at Edwards AFB, and, according to the Navy, the Mach 2 missile came through with flying colors. The vehicle was recovered and will be used again.

Haley to Address AMA

Andrew G. Haley, general counsel of the American Rocket Society and president of the International Astronautical Federation, will address a conference of the American Management Assn. at the Biltmore Hotel in New York City on Feb. 21. His topic will be "The Commercial Implications of Missiles, Satellites and Space Ships."

Sky Light

On Nov. 26, a cloud of sodium vapor was released from an Aerobee-Hi at an altitude of 80 miles above Alamogordo, N. M., lighting up a large area of the pre-dawn sky in the southwest.

An extension of the work being carried on by the Photochemistry Laboratory of the Air Force Cambridge Research Center since 1955 (December 1957, Astronautics, page 28), this particular experiment was part of Operation Smoke Puff. It was designed to demonstrate that an ion cloud could be artificially catalyzed, and that radio signals could be bounced off this cloud in the same way they are bounced off natural agglomerations of ions in the ionosphere.

The significance of this artificially catalyzed signal reflector, of course, lies in its controllability. In effect, it means that man will soon be able to set up his own "natural" relay stations where and when desired.

Push Coming on Development of Anti-Missile Missile

The question is no longer whether or not Russia has an ICBM. Rather, it is: "How is this country to defend itself against a 15,000 mph missile carrying a nuclear warhead?"

One answer—and presently the only apparently workable answer—is retaliation, say top military leaders. Still ICBM shy, the U. S. has the intermediate range Jupiter and Thor with which to face down the Soviet. These weapons will soon be coming off production lines, and, by the time the first IRBM unit is operational, the U. S. is expected to have concluded agreements with France and other European countries for IRBM bases. Then, of course, there is the Strategic Air Command with its nuclear retaliatory powers.

But retaliation can give little comfort to citizens in prime target areas or, for that matter, to the military with their need for home supply bases and uninterrupted production. Retaliatory power is insufficient. There is—and without question—a need for an adequate defense against the ICBM. And the big push is now on in this country for such a defense—the anti-missile missile.

Three to Make Ready

The first weapon to be mentioned in this regard was the Army's Nike-Zeus, under development by Douglas Aircraft and Western Electric. More recently, there was the official announcement of the Air Force's Wizard with Convair and Radio Corp. of America as the major contractors. And, reportedly, there is another AF anti-missile program, still unnamed, under the aegis of Boeing, General Electric and Ramo-Woolridge.

The Army figures its program is farther along than the others and has estimated that it could have the weapon ready by 1961 provided it could get a budget allotment of $6 billion. The AF has taken exception to the Army plan, questions the fact that the Army program is far enough along to warrant that great an expenditure.

No decision has been made as to which of the three programs will be carried through to production, and none is expected for some time. Moreover, to end interservice rivalry and facilitate development of the anti-missile weapon, both the Zeus and Wizard will be placed under a single manager—the first projects to be placed under this new concept in missile management. When the resultant anti-missile weapon has passed through R&D phases, it will be turned over to the military service that will operate it.

All three anti-missile missile programs now in the works actually date back several years. Representative Gerald R. Ford Jr. (R., Mich.) recently revealed that the U. S. had already spent more than $50 million on AMM development, and contracts for such work are being awarded almost every day.

Only recently for example, Western Electric Co. received a $5 million award for continued development work on the Army's Nike-Zeus program.

In Advanced Study Stage

All of these programs are said to be in an advanced study stage, although a good deal of the hardware which could be used in them already exists. Some Pentagon planners feel that an all-out push could produce operational AMM's, capable of destroying ICBM's with ranges up to 5,500 miles, as quickly as Russia could produce the long-range weapons.

Most Defense Dept. officials, however, are not so optimistic, although the feeling is growing that ICBM's may not be as difficult to bring down as was originally anticipated.

The reason may be found in the very nature of the ballistic trajectory, which is unvariable and can be computed quickly and easily. It is now felt that the best way to intercept and destroy an ICBM is by firing an AMM, flying in the opposite direction to it, into the same trajectory the ICBM is flying.

Since a warhead flying a ballistic trajectory is unguided and fixed, the problem of interception is not as complicated as it would be if it were controlled. Also, a direct hit would not be necessary. As the AMM would carry an atomic warhead, it could destroy the ICBM, either by collision, with debris from the blast or with heat.

Even so, "kill" expectancy would be low. Guidance would have to be extremely accurate and the problem of firing the AMM into the same trajectory as the ICBM would probably necessitate use of a multitude of launching sites.

Effectiveness of such a counter-weapon would, of course, depend on a highly efficient long-range radar system, capable of tracking an ICBM over distances of 5,000 miles or more. While the new radar developed at Columbia University (see October ASTRONAUTICS, page 8) represents a step in this direction, a good deal of work still remains to be done in this field.

Despite the many difficulties involved, there can be little doubt that the anti-missile missile will be getting a long, hard look in the months that lie ahead.

British Missile Industry Moves into High Gear

Britain is heavily engaged in providing the R.A.F. with its final generation of manned aircraft, the supersonic P.1 interceptor and the Victor and Vulcan heavy bombers with their "stand-off" flying bombs—the intermediate stage to an all-missile force.

Meanwhile, the main weight of the military research and production effort has been transferred to the large-scale guided weapons program upon which the industry has now embarked to meet the future needs not only of the R.A.F., but also of the Army and Royal Navy.

Wide collaboration is needed to produce highly complex pieces of mechanism, such as the Bloodhound and Thunderbird missiles, and the Seaslug, a robot anti-aircraft weapon. Armstrong Whitworth Aircraft Ltd. is "coordinating contractor," while nine other companies, including Sperry Gyroscope and General Electric, are closely associated in the development of this weapon system.

AIA Film Features Missiles

To provide the public with guided missiles progress, a 26-min film featuring footage of the pilotless aircraft types being built and developed for the U. S. Armed Forces has been completed by the Aircraft Industries Assn. Titled "Men and Missiles," and intended primarily for use by independent T.V. stations, the film traces history from the first "pilotless torpedo" of 1917 to the hypersonic ballistic missiles now in use. Also included is an explanation of the Vanguard earth satellite.

More Matadors to Taiwan

The Defense Department has announced that the USAF guided missile unit on Taiwan will be reinforced with additional TM-61 Matadors. Under the direction of the Tactical Air Command and assigned to the Pacific Air Force, the new Matadors are expected to materially bolster defense capability of AF units assigned to Formosa.

Inertial Guidance Plant Goes into Operation

St. Petersburg, Fla.—This city where curbs slope gently to the road and old people come to retire is going through a change of life. Industry is moving into the area, bringing with it young blood and new vitality. The latest facility to open its swinging glass doors on a broad palm-studded approach apron is Minneapolis-Honeywell's new inertial guidance plant.

Possibly the first plant built exclusively for the development and manufacture of inertial guidance systems, the newly opened facility already has $3 million in contracts to keep its 450 personnel occupied. This does not include the inertial guidance work in progress at Minneapolis-Honeywell's other Aeronautical Div. facilities.

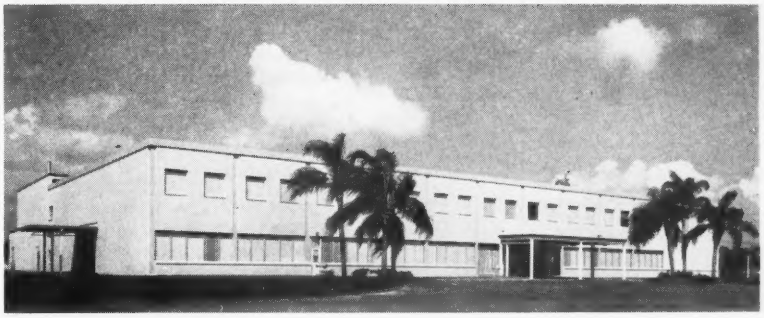
In all, the company is supplying guidance systems or components for 20 different rocket and missile programs. Among those that can be mentioned are the following: Vanguard, Titan, Thor, Snark, Sergeant, Regulus, Q-4 and Wagtail.

The guidance units for Vanguard and Titan are similar advanced autopilot reference systems which are essentially strapped-down inertial platforms. Wagtail is a new air-to-surface missile for which the company is prime contractor. Like other ASM's, Wagtail does not require a guidance system as precise as inertial and so will use a more simple gyro setup.

At present, the St. Petersburg plant is equipped to produce five complete inertial systems a month. But, according to plant general manager Melvin Fedders, the company has already purchased steel for a new production facility at St. Petersburg on which construction is expected to start shortly.

The present $4\frac{1}{2}$ million structure occupies only 98,000 sq ft of the 95-acre site, which is actually located just north of St. Petersburg. Designed and built to be as thoroughly shockproof as possible, the facility has a number of interesting features. For instance, to keep the ground around the plant absolutely dry and shortstop vibrations (which travel more easily in wet soil), the contractors cut a big moat or drainage ditch into the ground around the plant.

Minneapolis-Honeywell Regulator Co. is betting big on inertial guidance because of the system's long-range accuracy and independence of external guideposts and, hence, resistance to jamming. Recent research has uncovered an important weakness in the system, i.e., the sensitivity of the system's electronic components to radioactivity. But even this can be counteracted, at least in conditions encountered so far, according to M-H engineer George Rusler Jr.



HONEYWELL'S NEW FLORIDA FACILITY: Foolproof missiles from a dust-proof, damp-proof, shockproof plant.

In addition, the company is carrying out some rather basic studies concerned with the application of inertial guidance systems to future extraterrestial vehicles, and possible use in the near future of spinning electrons in place of man-made gyroscopes. Studies such as these, the firm believes, will lead to better guidance systems and broader markets.

As a result, Minneapolis-Honeywell foresees a future for its new operation almost as bright as the Florida sunshine itself.

Solids Score High On Reliability

In actual flight tests, Thiokol Chemical Co.'s large solid propellant motors have achieved a reliability record of 97.5 per cent, according to Thiokol president J. W. Crosby.

Speaking at the formal opening of the company's new Utah Rocket Div. outside Brigham City, Crosby pointed out that the missile most extensively proved in flight tests has been Lockheed's X-17, the re-entry test vehicle developed for the Air Force ICBM program. Thiokol developed and produced the solid propellant rocket engines used in all three stages of the vehicle.

Army Chief of Staff Asks Halt on Missile Rivalry

Gen. Maxwell D. Taylor, Army Chief of Staff, said in an interview late in October that inter-service rivalry in guided missiles has gone far enough and the time has come when a decision should be made on what type of ballistic missiles should be produced.

Gen. Taylor noted that rivalry is good up to a point, and that it has kept the competing services on their toes. However, he went on, it is extremely important to determine when the point is reached when such rivalry will disrupt our efforts and reduce effectiveness.

He also called for an even greater effort in developing missiles, explaining that he was referring not only to the financial side of missile development, but also to the physical and mental effort going into current missile programs.

Radiation Research Studies Intensified

No bonus for nuclear work. That, in effect, is the result of a recently completed study carried out by the Air Research and Development Command for the Air Force.

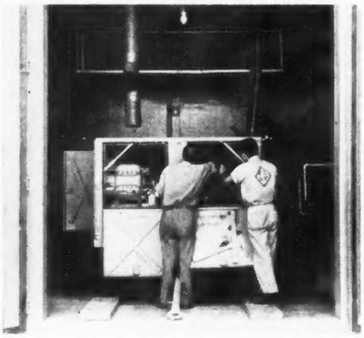
The study, according to ARDC, shows that personnel exposed to radiation dangers obtain greater satisfaction from proper clothing and protective devices than from extra or "hazard" pay. The usual practice in industry and government, adds ARDC, is to provide paid clean-up time and company-purchased work clothes for those engaged in dangerous or unpleasant work.

Somewhat afield is another radiation study now under way near atomic pile sites at Arco, Idaho, and Los Alamos, N. M. Boeing Airplane Co. is carrying out tests at these sites on its Bomarc IM-99 missile to determine what effects nuclear radiation will have on transistors used in the vehicle.

Although the newer guidance systems such as inertial platforms are not susceptible to jamming, they may have an electronic Achilles heel. The purpose of the present program is to discover what effect nuclear radiation has on electronic components of guidance and control systems and, if there are any, what can be done to counteract them.

new equipment and processes

Large Environmental Chamber



One of the largest low-temperature environmental test chambers available on the West Coast for commercial testing is in use at the Fullerton plant of American Electronics, Inc. Made by Moore & Hanks Co., the chamber can test packages and units up to 5 tons.

Inside dimensions of the chamber are 21 ft long, 13 ft high and 15 ft wide. It has a main access door 9 by 12 ft and two auxiliary doors 3 by 6 ft. A methol alcohol-dry ice heat exchanger system is available which can hold the chamber at −95 C with no heat load, and at −65 C with a live heat load of 300,000 Btu.

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Sealed Switch: A new type of switch, hermetically sealed, resistant to corrosion and unaffected by high ambient pressures, is available for use in aircraft, missiles and rockets. A balancing system automatically equalizes environmental pressures on the actuating mechanism. Switches can be furnished with an actuation force of either 10 or 32 oz maximum. Haydon Switch, Inc., Waterbury 20, Conn.

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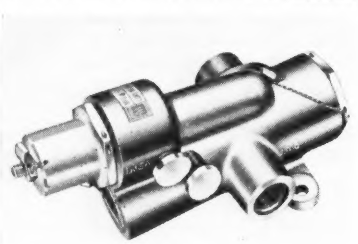
Reducer for Pneumatic Pressure



Close control of outlet pressure over a wide range of inlet pressures and outlet flows is a feature of Weston pneumatic pressure reducers. Performance characteristics of one of the many types available are: Inlet pressure, 3000 psi; rated flow, up to 75 lb/min; outlet pressure, 200 to 2800 psi; relief presure, 115% of outlet pressure; temperature range, −65 to 180 F. Weston Hydraulics, Ltd., 10918 Burbank Blvd., North Hollywood, Calif.

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Foil-Type Strain Gages: Four new SR-4 rosette strain gages with higher sensitivity and stability than previous gages are available in quantity. These gages, of bonded filament type construction, need no lateral corrections except in the most precise testing problems, can withstand temperatures as high as 300 F in continuous service, and are thinner, more flexible and more easily applied than bonded wire gages. Electronics & Instrumentation Div., Baldwin-Lima-Hamilton Corp., Waltham 54, Mass.

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Flush Head Bolts and Driver

Hi-Torque wrenching recess permits tighter tightening and easy removal of fasteners without driver slippage and resulting damage to work. The slotted recess permits safe application of the high installation torques needed to preload fasteners of the highest available test strengths. Standard Pressed Steel Co., Jenkintown, Pa.

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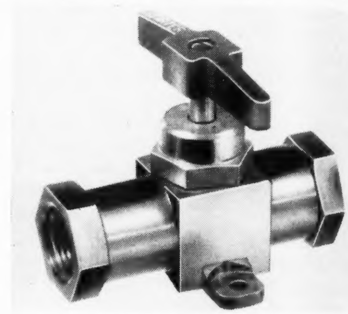
Air-Hydraulic Test Stands: Adaptable for both hydrostatic and functional testing is a line of air-hydraulic aircraft test stands. Reciprocating pumps deliver hydraulic fluid under pressure as required. Pressure is maintained under full flow or no-flow conditions while the pump is almost motionless. When high rate of flow under pressure is needed, the unit delivers volume as required by demand. Ledeen Mfg. Co., 3350 No. Gilman Rd., El Monte, Calif.

Straight-Through Control Valve



A small straight-through, directional control valve can be used with pneumatic, most fuel and hydraulic oil systems, and for most liquid or gaseous propellants. It has an operating torque of 20 in./lb. Eastern Aircraft Products Corp., Orange, N. J.

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Missile Air Tank: Consumable EB weld inserts used to join the ends of a guided missile air tank helped save weight and get x-ray quality welds of high strength. The tank, 60 in. long by 30 in. diam, has to contain air under 300 psi pressure and weigh less than 600 lb. Use of the inserts eliminates both the need for and the weight of back-up rings. In addition, they allow welding conveniently from one side only. Arcos Corporation, Philadelphia 43, Pa.

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Molybdenum Tubing: Molybdenum seamless tubing is now produced by cold extrusion methods. Normally, molybdenum is hot worked at 2000 F or higher, but difficulties result from volatile oxide formation above 1300 F. Cold extrusion permits precision tolerances after only a few press operations. Tubing for specific applications is being considered in the diameter range of 1 to 6 in. Lengths over 5 ft are feasible and walls from 0.030 to 0.125 in. have been produced.

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Metal Production: A simple, inexpensive way to produce purer high melting point metals has been developed at Illinois Institute of Technology. The new process produces titanium, zirconium, chromium, hafnium, niobium and vanadium directly from their oxides. In the new method, the oxides of the metals to be produced are reacted with aluminum under such conditions that complete removal of oxygen is accomplished. Illinois Institute of Technology, 35 W. 33 St., Technology Center, Chicago 16, Ill.

Light Measures Surface Flatness

An improved monochromatic light for measuring flatness is 11 by 14 in. in size, with a work stage 10 in. square. A heavy duty 9000-v transformer provides an average of 40 fcp at the diffusing glass. The light head may be tilted back and adjusted for height, or swung around. Crane Packing Co., 6400 Oakton St., Morton Grove, Ill.

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Titanium Alloy: Rem-Cru has developed a new alloy with high strength at normal and elevated temperatures. The new bar and forging alloy shows promising properties for jet engine disks and blades, airframe forgings and other parts. The alloy, C-130-AMo, has a nominal composition of 6.5% aluminum and 3.75% molybdenum. Rem-Cru Titanium, Inc., Midland, Pa.

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Adhesive Tape: Pressure sensitive self-stick Teflon adhesive tape can be readily attached to any metal, glass or plastic and most other surfaces. The silicone adhesive is available in widths up to 2 in. in 36-yd rolls of 0.006 in. thickness, and 18-yd rolls of 0.013 in. thickness. Both types can also be supplied in 12-in. sheets. Chicago Gasket Co., 1271 West North Ave., Chicago 22, Ill.

Motion Picture Missile Camera

An improved missile camera, the Fastax WF-17, records both mechanical and electrical data on the same film. The combination high speed motion picture and oscillographic camera takes 100-ft daylight loading spools, and can be used for either picture or oscillographic recording independently. Wollensak Optical Co., Rochester, N. Y.

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Refractory Cement: CA-9 cement will hold metal to metal, glass or ceramics at temperatures between −420 and 1000 F. The adhesive is dielectric and shock-resistant throughout its temperature range. The cement will attach surface-temperature transducers, strain gages and lead wires to any guided missile. Charles Engelhard, Inc., 850 Passaic Ave., East Newark, N. J.

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Dielectric Coil Forms: DuPont Mylar thin-wall coil forms have been developed as a solution to insulating problems where space is limited. Wall thicknesses of from 0.002 to 0.010 in. can be supplied. The tubes resist moisture, solvents and chemicals, have high dielectric strength, and will neither dry nor become brittle with age. Precision Paper Tube Co., 2035 W. Charleston St., Chicago 44, Ill.

Rubber and Plastic Parts

Kotokast, a new concept in forming rubber and plastic parts and products for experimental engineering purposes, has proved effective in the fabrication of prototypes. Using either plastics, latex or various synthetic elastomers, the process can achieve economies in development programs where prototype experimentation is desirable before production commitment. Minnesota Rubber & Gasket Co., 3630 Wooddale Ave., Minneapolis 16, Minn.

PRODUCT LITERATURE

Checkout Equipment. The use of rapid automatic checkout equipment (RACE) for maintenance of weapons systems is described in a 6-page preprint. Hours would be needed merely to disassemble a missile to get at all the subsystems, yet operational scheduling permits only 10 to 30 min for live checkout. Automatic instrumentation is mandatory to reduce the time element to practical limits. Microwave Electronics Div., Sperry Gyroscope Co., Div. of Sperry Rand Corp., Great Neck, N. Y.

Tape Instrumentation. Four kinds of Ampex magnetic tape instrumentation are described in a 16-page booklet—data acquisition, time delay, data storage and transfer, and programming. Details are given on what magnetic tape-recording can do in a diverse collection of applications. Instrumentation Div., Ampex Corp., 934 Charter St., Redwood City, Calif.

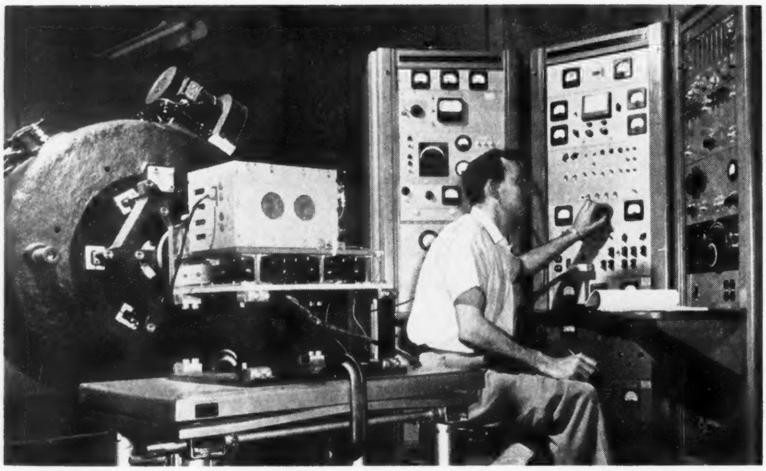
Heat-Resistant Alloys. Titanium carbide alloys and their many applications in aircraft and missile equipment are presented in bulletin B-444. Illustrated are simple and complex shapes that have been used at temperatures ranging above 1800 F. Physical properties of 13 different Kentanium compositions are tabulated and charted to show the effects of temperature and time of exposure. Kennametal Inc., Latrobe, Pa.

Shock Tester. A brochure describes the Hyge shock tester which provides for accurate simulation of shock experienced by equipment in actual use. It is capable of producing thrusts up to 12,000 lb instantaneously and exactly with precision wave-form control. Widely varying accelerating and decelerating forces can be applied for controlled time periods. Rochester Div., Consolidated Electrodynamics Corp., 1775 Mt. Read Blvd., Rochester 3, N. Y.

Synthetic Lubricants. "Jet Age Lubricants," a manual on the development, testing and application of engineered lubricants has been released. Charts and graphs demonstrate the physical properties of Anderol lubricants in comparison with petroleum lubricants in such factors as volatility, oxidation stability, evaporation, etc. Lehigh Chemical Co., Chestertown, Md.

Data Reduction. Brochure 5-03-120 details the use of Datatron in rapidly reducing to usable form the great quantities of raw data obtained from mass spectrometer analyses. The inversion of a matrix of coefficients and the computation of a mixture's per cent composition are documented. Brochure 5-02-110 explains how the Millisadic analog-to-digital converter is linked to Datatron by modifications permitting the computer to read and process test data directly from the magnetic tape. ElectroData, 460 Sierra Madre Villa, Pasadena, Calif.

Federal Telecom—Supplier of Missile "Brains"



Missile component undergoes shake test at Federal Telecommunication Laboratories in Nutley, N. J.

A recent announcement crediting accuracy of the Army's Lacrosse surface-to-surface missile to its precise guidance system, developed by Federal Telecommunication Laboratories, Inc., has focused attention on this research division of International Telephone & Telegraph Corp., a major supplier of missile "brains."

With acceptance of the Lacrosse guidance system by the Army, FTL engineers, together with Martin and Cornell Lab, have turned their attention to modifications and improvements, adding mobility, range and accuracy.

In addition to Lacrosse, FTL has had a hand in the Bomarc, Rascal and Talos guidance systems with more in the future.

Race Into Space

(CONTINUED FROM PAGE 35)

highly reactive substances in ramjets be justified in preference to the more conventional hydrocarbon fuels.

• To Berl and Renich, the physical state of the ramjet fuel was of no fundamental significance. Robert L. Wolf and James W. Mullen of Experiment, Inc., disagreed, feeling that solid fuels offer some definite advantages over liquids for ramjet operation.

From their study of solid-fuel ramjets, the authors decided that under certain conditions solid ramjets showed superior performance. In addition, they were simpler and therefore more reliable. Under the sponsorship of Navy BuOrd and the Applied Physics Lab of Johns Hopkins, Experiment, Inc., conducted actual flight tests with solid ramjets. The results of these tests, according to the authors, support the argument for such vehicles.

Moreover, they added, two types of fuel charges are now available in a sufficiently advanced developmental state to warrant consideration in current application studies. Both types consist of finely powdered fuel (magnesium) mixed with small amounts of inorganic oxidizer (sodium nitrate), and molded under pressure into the desired geometric shape. One is an annular charge; the other, a modification, is a split-flow annular charge.

Among possible applications for solid-fuel ramjets, the authors suggested air-to-air, air-to-ground, ground-to-air, ground-to-ground and intercontinental missiles; flat trajectory, high-penetration antitank ordnance; simple projectiles for saturation bombardment beyond rocket range; and carrier vehicles for aerodynamic test models.

In the so-called race to space, emphasis today is being placed on the development of better propellants and powerplants. Important as power is, it is not enough by itself to take man into and through space.

• Future space travelers, said Peter A. Castruccio of Westinghouse, will still face the problem of guiding their flight and of establishing and maintaining reliable communication channels with their home bases and with other space travelers. While both problems are difficult, they are not unsolvable.

Loran System Might Work

For interplanetary navigation, Castruccio suggested that a Loran (long range navigation) system might work, provided that it would operate in three dimensions instead of the present two. Such a set-up would require at least four omnidirectional transmitting beacons in known orbits around the sun. The position of the ship within the solar system then could be determined by measuring the differences in the times of arrival of pulses issued by the four beacons, which would transmit pulses correlated in time as in the present Loran system.

With present state of the art, and assuming perfect conditions, effective range of omnidirectional transmission could reach 47 billion miles, said the author. By 1970, he believes, this range will be improved by a factor of 10.

In communication, the problem becomes somewhat more difficult. The base-to-ship range for omnidirectional transmission and reception on voice communication with present equipment, Castruccio calculates, is 1.4 million miles. He believes this could conceivably be increased to 50 million miles by 1970. Greater ranges could be achieved with code communication, he noted.

Ship-to-base communication, on the other hand, suffers from the limitations of power and weight of airborne equipment. Thus restricted, the voice range from ship to base, Castruccio estimated, will be about 16 million miles.

With the development in techniques anticipated by 1975, the maximum range attainable for a pulsed communication system will be about 1 trillion miles (or 0.176 light years). This is inadequate for communication to the nearest stars, Castruccio noted, but it should suffice for setting up communication links within the planets of our solar system.

Interplanetary Navigation

Interplanetary navigation is certainly a more spectacular subject than intercontinental navigation, but it is also a less important one, at least for the present. Missile men today are more concerned with getting unmanned vehicles from one point to another here on earth. To them, the important question is: What is going on in the development of present guidance systems?

• One of the newest systems in this field is inertial guidance. In his analysis of an inertial guidance system, D. B. Duncan, Autonetics Div. of North American Aviation, considered the problem of guiding a spherical nonrotating body. His investigation, Duncan reported optimistically, leads to the supposition—borne out by experiments so far—that improvements

in inertial instruments, in accuracy of initial alignments, and so on will pay off directly in enhanced guidance accuracy without any foreseeable limit.

• Improvement in the accuracy of initial alignment is not the only problem in the way of better inertial guidance systems. Equally important, said Robert E. Roberson of Autonetics, is improvement in the calculation of impact points, particularly for long-range ballistic rockets.

Oblateness Raises Problems

One of the big problems here, said Roberson, is that the earth is oblate, and not spherical as it should be. (It would be even better, of course, if it were flat.) Given a set of initial conditions (position and inertial vector velocity), it would be comparatively easy for guidance men to determine a ballistic trajectory over a spherical earth. But an oblate earth, even if it has the same mass, exerts a different force on the rocket and, as a result, alters its path.

To determine this oblateness effect, many missile men have approached the problem numerically, using high-speed digital computation. This is the popular method of attacking the problem and it has proved fruitful. But there are times, Roberson noted, when an analytical approach would be better. And, in his paper, "Oblateness Correction to Impact Points of Ballistic Rockets," the author developed an analytical method which he believes will prove both workable and practical.

In General

In all, 62 papers were scheduled for presentation at the 12th Annual ARS Meeting. This does not include papers from the classified session on liquid rocket propellants. In addition there was a special panel discussion on the International Geophysical Year.

The purpose of any ARS meeting, of course, is to bring members up to date on the state of the art. But this particular meeting, coming as it did on the heels of Russia's recent satellite successes, actually served a dual purpose. Not only did it acquaint those attending with many significant developments in almost every aspect of rocket and missile technology, but, even more important, it indicated quite clearly that the U.S.S.R. is a long way from being the winner in the race into space.

Air Force To Activate Long-Range Missile Unit

The Air Force has scheduled activation of the first Snark guided missile squadron early in 1958. This is the first intercontinental guided missile to come into operational use. The squadron will be assigned to the Strategic Air Command.

Missile units will be so positioned as to reduce problems of noise and insure that missiles, if fired, will not pass over heavily populated areas. Missiles will not be launched from operational sites except in case of war. Crews will practice actual firing at an established range, such as Patrick AFB.

Missile Marker

The Army has approved issuance of a special badge to personnel who qualify as basic, first-class and expert missilemen. The badge will be in the form of a component bar inscribed with the word "Missile" and will be attached to the appropriate basic qualification badge. Criteria for the different ratings have not yet been established.

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